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GROUND WATER

IN

NORTHEASTERN PENNSYLVANIA

By
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of the U. S. Geological Survey

With Analyses by
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(Prepared in cooperation between the United States Geological Survey and
the Pennsylvania Topographic and Geologic Survey)

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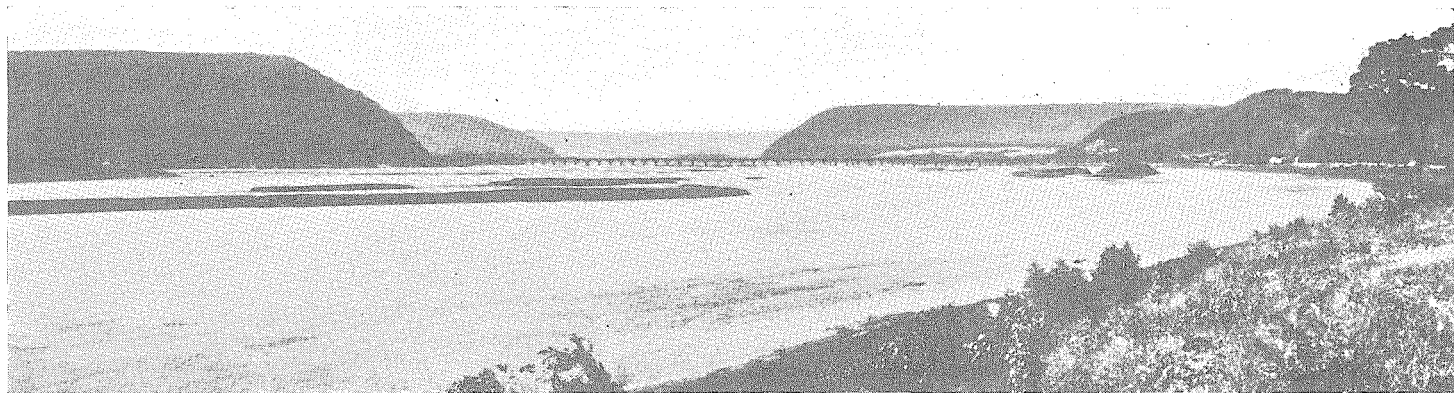
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A. View of the Susquehanna Water Gap looking northeast from a point $1\frac{1}{4}$ miles south of Rockville, Dauphin County



B. Terraces on the south side of the North Branch of Susquehanna River below Beach Haven, Luzerne County

GROUND WATER IN NORTHEASTERN PENNSYLVANIA

By STANLEY W. LOHMAN

ABSTRACT

This report describes the surface features, stratigraphy, and geologic structure and the sources and chemical character of the ground water in an area covering 7,087 square miles in northeastern Pennsylvania, including Carbon, Columbia, Lackawanna, Luzerne, Monroe, Montour, Northumberland, Pike, Schuylkill, Susquehanna, Wayne, and Wyoming Counties, the northern three-fifths of Dauphin County, and about 50 square miles of northern Lebanon County. The area is drained entirely by the Delaware and Susquehanna Rivers and their tributaries. It includes parts of two geomorphic provinces—the Appalachian Plateaus province and the Valley and Ridge province, both of which are subdivisions of the Appalachian Highlands.

The consolidated rocks of the area range from the post-Pottsville formations, of Pennsylvanian age (youngest), to the Juniata formation, of Upper Ordovician age (oldest)¹. All the rocks are later than the Taconic disturbance, and the Juniata formation and the overlying Tuscarora sandstone (Silurian) rest unconformably on the Martinsburg shale (Ordovician), which is exposed south of the area. There are no pronounced stratigraphic breaks above the unconformity at the base of the Silurian except in Dauphin and Lebanon Counties, where all of the Lower Devonian and late Silurian are absent, owing either to a fault or to an unconformity. The youngest consolidated rocks, the post-Pottsville formations, contain the valuable anthracite beds, which are extensively mined in several large synclinal basins within the area. Anthracite is also obtained locally from the Pottsville formation and the Pocono sandstone.

More than half of the area is covered with glacial drift, mostly of Wisconsin age, although Illinoian and Jerseyan drift occurs south of the Wisconsin drift border which traverses the middle of the area. The recent alluvium along the larger streams that drain the coal basins contains considerable finely divided coal that is recovered by dredging at numerous points.

Within the densely populated and industrialized coal basins ground water is used only in a very few places, and municipal, industrial, and domestic needs are supplied almost exclusively by surface water. Within the coal basins the water level has been lowered by continual pumpage of mine water, and most of the little water that remains in reach of wells is unfit for ordinary use. The water thus obtained from the mines is largely utilized for washing coal, after which it is discharged into the streams.

Outside the coal basins the larger municipal supplies are obtained from surface water, but the domestic, industrial, and smaller municipal needs are supplied chiefly by ground water. In the rural regions domestic supplies are obtained largely from dug wells, but small springs and drilled wells are also used extensively. Industrial and municipal supplies are obtained chiefly from drilled wells and springs.

North of the Wisconsin drift border and for some distance south along the major drainage channels, glacial drift supplies all the dug wells and a few of the drilled wells. Large supplies of water can be obtained from glacial outwash in some places by means of properly constructed drilled wells using well screens, but very few attempts have been made to recover large quantities of water from any of the unconsolidated deposits.

¹ The Pennsylvania Topographic and Geologic Survey classes the Juniata as Silurian.

Most of the drilled wells in the area obtain adequate supplies of water from sandstone, but a few obtain water from conglomerate, shale, or limestone. Most of the rock formations contain numerous beds of sandstone that can generally be reached by wells of moderate depth. The sandstones are in the main rather firmly cemented, and the water is contained chiefly in fractures, joints, and bedding planes. Shale yields small but generally reliable supplies. Limestone occurs only in a few places along the southern and western borders of the area and is of importance as a source of ground water only in parts of Columbia, Montour, and Northumberland Counties, where it yields large supplies of hard water to wells that encounter solution channels, but it may yield very little water where solution channels are not encountered.

Artesian conditions are related to the geologic structure. In the Appalachian Plateaus province, where the strata are nearly horizontal over large areas, flowing wells are not numerous but occur locally. In the Valley and Ridge province flowing wells are obtained in many places on the flanks of synclines or monoclines. A few flowing wells occur in glacial drift.

With few exceptions, the chemical character of the ground water is entirely satisfactory for most purposes. Water from glacial drift or light-colored sandstone or shale generally contains small amounts of dissolved mineral matter and is generally soft. Water from dark-colored shales or sandstone generally contains more dissolved mineral matter and in some places is noticeably hard. Water from limestone ranges from moderately hard to very hard.

INTRODUCTION

PURPOSE OF THE INVESTIGATION

The investigation that forms the basis of this report was a part of a larger program undertaken by the Pennsylvania Topographic and Geologic Survey in cooperation with the United States Geological Survey to determine the ground-water conditions in the entire State. By far the most important industry in northeastern Pennsylvania is the mining of anthracite. The largest cities and the major industrial enterprises are in the main situated within the several coal basins, where municipal and industrial water supplies are derived almost exclusively from surface water. In the territory surrounding the coal basins, however, municipal, industrial, and domestic supplies are to a great extent derived from ground water by means of wells and springs. Many of the present users of ground water are confronted with the problem of obtaining larger quantities of water. In some parts of the area the recent advent of paved roads has opened up new lands for settlement, and in these parts ground-water supplies are being developed. It was with the hope of helping to solve these present-day problems, as well as problems that will doubtless arise in the future development of the area, that this investigation was undertaken.

GEOGRAPHY

LOCATION OF THE AREA

The area described in this report covers 7,087 square miles in the northeastern part of Pennsylvania and includes Carbon, Columbia, Lacka-

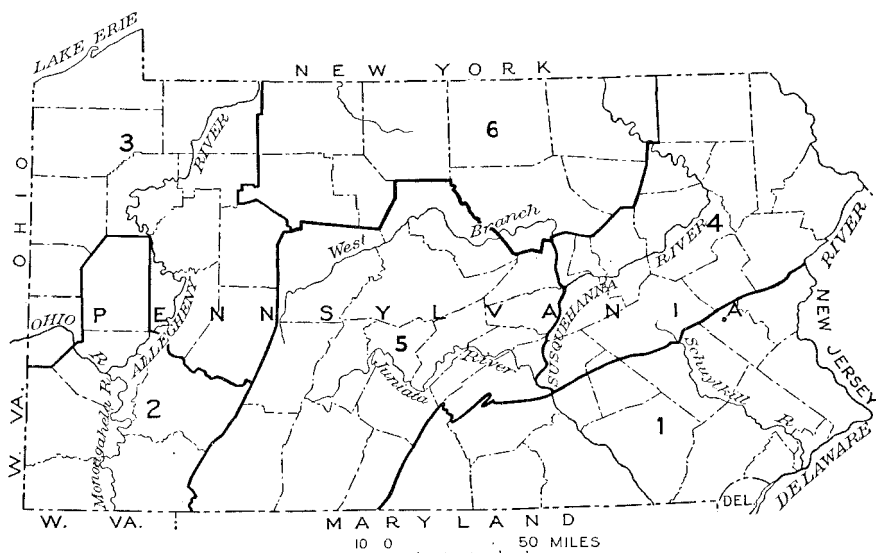


Figure 1. Index map of Pennsylvania showing areas covered by this series of ground-water reports

1. Bulletin W2, by George M. Hall, 1934.
2. Bulletin W1, by Arthur M. Piper, 1933.
3. Bulletin W3, by R. M. Leggette, 1936.
4. Bulletin W4, by S. W. Lohman, 1937.
5. and 6. Manuscripts by S. W. Lohman in hand.

wanna, Luzerne, Monroe, Montour, Northumberland, Pike, Schuylkill, Susquehanna, Wayne and Wyoming Counties; the northern three-fifths of Dauphin County and the northern fifty square miles of Lebanon County. The area is bordered on the north by the State of New York, on the east by New York and New Jersey, and on the south and west by the adjoining counties of Pennsylvania. Most of the area lies between the meridians 75° and 77° and parallels 40°-30' and 42°.

All the anthracite fields in Pennsylvania lie within the area described in this report and are shown on plate 1 under the term "post-Pottsville formations." In 1930 there were 300 anthracite mines in this area.

POPULATION

According to the census of 1930, the 12 complete counties described in this report (exclusive of Dauphin and Lebanon Counties), had a population of 1,359,027 and an average density of population of 193 to the square mile, as compared with 215 for the entire State. In these 12 counties 66½ per cent of the population was found in towns of 2,500 or more inhabitants. There are 20 cities in the area that have more than 10,000 inhabitants, the two largest of which are Scranton, with 143,433, and Wilkes-Barre, with 86,626. The greatest density of population is found in the several anthracite fields, in which are located 18 of the 20 largest cities. The population figures of the counties and larger towns are given in the county chapters of this report. Lackawanna County has the greatest density of population, with 688 inhabitants to the square mile, and Pike County has the smallest, with only 13.8 inhabitants to the square mile.

AGRICULTURE

In the 12 counties in 1930 there were 21,625 farms, averaging 96.67 acres each. Susquehanna County ranked first, with 3,170 farms, and Pike County twelfth, with 528 farms. Of the total land area in the 12 counties about 50 per cent was devoted to farming. Montour and Susquehanna Counties ranked first and second, with 81 and 78 per cent under cultivation, and Pike County ranked twelfth, with only 19 per cent.

MANUFACTURING

Manufacturing is a leading industry in the coal basins and is carried on to a small extent in other parts of the area. In 1929, according to the Census Bureau, there were in the 12 counties 1,570 manufacturing establishments, whose annual products were valued at \$5,000 or more each, and these establishments employed 79,487 wage earners and turned out products valued at \$374,735,341. Luzerne County ranked first in manufacturing.

CLIMATE PRECIPITATION

Annual precipitation records have been kept at 30 United States Weather Bureau stations in this area. Although the records at one station began in 1857 and at two others in 1866, the records prior to 1885 are fragmentary, and some of the records were begun since 1920. The average annual precipitation at stations having records of 9 years or more is 43.67 inches. The stations having the highest and lowest precipitation are Mauch Chunk, with an annual average of 48.94 inches, and Scranton, with an annual average of 38.69 inches. The maximum annual precipitation on record in this area was 72.36 inches at Blooming Grove, Pike County, in 1889, which was the year of the famous Johnstown flood. The minimum annual precipitation on record was 23.65 inches at Milford in 1917. However, in 1876 the precipitation was only 24.00 inches at Blooming Grove, and in 1930 the precipitation at Catawissa, Lansford, Scranton, and Sunbury ranged from 25.26 to 26.45 inches. Moreover, records for Milford were kept only to 1920 and those for Blooming Grove only to 1894, and hence 1930 may have in fact been drier than 1876 or 1917.

The prevailing winds blow toward the west, northwest, and southwest, so that in general the heaviest precipitation occurs along the east slope of the Pocono Mountain plateau. The Weather Bureau figures showing monthly distribution of normal precipitation are greater each month for stations in the Delaware Basin than they are in the Susquehanna Basin. Although the annual rainfall is fairly well distributed throughout the year, the heaviest precipitation occurs in June, July, and August, with the maximum in July, and the minimum precipitation occurs in February and November. Thus the rainfall is greatest during the growing season, when it is of the most benefit to crops.

The average annual snowfall is about 50 inches, and nearly all of it occurs between November 1 and April 30, although in some years traces of snow have been recorded in October and May.

TEMPERATURE

Records of temperature at 10 United States Weather Bureau stations in northeastern Pennsylvania up to 1931 show that the mean annual temperature ranges from 44.4° F. at Mount Pocono to 50.8° F. at Catawissa and averages 48.2° F. July, with an average mean temperature of 70.3°, is the warmest month, and January, with an average mean temperature of 26.2°, is the coldest. Temperatures as high as 104° have been recorded at Catawissa and temperatures as low as —35° have been recorded at Mount Pocono. In general, however, there are only 5 to 10 days in a year when the temperature is 90° or above, and 115 to 175 days in a year when the temperature is 32° or below. The first killing frost

in the fall generally occurs late in September or early in October, but has occurred as early as September 4 and as late as October 16. The last killing frost in the spring generally occurs during the latter part of April or the middle of May but has occurred as late as June 9. The length of the growing season is usually 120 to 180 days.

SOURCES OF INFORMATION

PUBLISHED REPORTS

The Second Geological Survey of Pennsylvania published reports from 1881 to 1883 on the geology of all the counties within this area except Carbon, Schuylkill, Dauphin, and Lebanon, but geologic maps of these four counties were made between 1874 and 1884 and first published in 1885. These reports, together with a survey of the anthracite fields, were later summarized by J. P. Lesley, State geologist, in the summary final report of the Second Geological Survey. Most of the geological data here presented were taken from these reports and maps, which contain a wealth of information on the geology of the area. Later reports, chiefly those of the Pennsylvania Topographic and Geologic Survey and the United States Geological Survey, have also been consulted and are listed in the bibliography and acknowledged by footnotes throughout this report.

As a basis for locating wells and studying the geologic and hydrologic features of the region, the topographic maps of the United States Geological Survey were used so far as available. In parts of Susquehanna, Wayne, Wyoming, Columbia, Montour, and Northumberland Counties for which no topographic maps were available, the public-road maps of the Pennsylvania Department of Highways were used.

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FIELD WORK

The field work forming the basis of this report was begun July 1, 1930, under the immediate supervision of R. M. Leggette, who spent 3 weeks with the writer in the field. The writer spent 4 months in the field during the summer of 1930 and about 3 weeks in the summer of 1931 and was visited in the first field season by Messrs. R. M. Leggette and D. G. Thompson of the United States Geological Survey. The investigation was conducted under the direction of O. E. Meinzer, geologist in charge of the division of ground water, United States Geological Survey.

Records of wells and springs that furnish public, industrial, and domestic supplies were collected, and well owners and drillers were interviewed. Only those village, borough, and city water supplies that utilize ground water were investigated, no study being made of those using water from streams or lakes. The data consist of well logs, well depths, depths to water level, artesian head, nature and age of water-bearing material, yield, draw-down, temperature of water, use of water, and relation to local or regional conditions. Some time was devoted to a study of the glacial and river deposits and of the hard-rock formations.

In order to determine the chemical character of water in different parts of the area, 106 samples were collected from wells and springs, most of them from municipal or industrial supplies. These samples were analyzed in the laboratories of the Geological Survey in Washington, D. C., by Margaret D. Foster, L. A. Shinn, and K. T. Williams.

The records of 1,161 representative wells, 82 municipal water supplies using ground water, and 106 chemical analyses of water from wells and springs are tabulated in the county descriptions of this report.

ACKNOWLEDGMENTS

This report would not have been possible had it not been for the wholehearted cooperation of the well drillers and well owners throughout the area. Individual mention of all who have contributed in this manner is, however, impracticable. Material assistance was rendered by Mr. R. D. Berninger, results engineer of the Stanton Operating Co., of Pittston; Mr. Lutze, engineer of the Hudson Coal Co.; Mr. L. L. Tallyn, division engineer of the Delaware, Lackawanna and Western Railroad; Mr. Paul Sterling, engineer of the Lehigh Valley Coal & Navigation Co., of Wilkes-Barre; Messrs. Hold and Sterner, superintendent and engineer, respectively, of the Nesquehoning colliery of the Lehigh Valley Coal & Navigation Co.; Mr. John Bevan, chief engineer of the Philadelphia & Reading Coal & Iron Co.; and Mr. George W. Moore, district engineer, Pennsylvania Department of Health, Harrisburg. The writer is indebted to Mr. L. D. Matter, district engineer, and Mr. Bernard S. Bush, assistant engineer, Pennsylvania Department of Health, Wilkes-Barre, for data on municipal supplies using ground water. Mr. Bush also furnished valuable data on drought relief work carried on under his technical supervision (see p. 40). Messrs. G. H. Ashley, State geologist; R. W. Stone, assistant State geologist, and Bradford Willard, of the Pennsylvania Topographic and Geologic Survey, and Messrs. G. W. Stose and Charles Butts, of the United States Geological Survey, contributed valuable advice. The illustrations were drawn in final form by Miss M. M. Johnstone of the Pennsylvania Topographic and Geologic Survey.

SURFACE FEATURES

RELIEF

The area as a whole has a relief of more than 2,400 feet. The highest part is in southeastern Susquehanna County, where North Knob rises 2,684 feet above sea level. The lowest part lies along the Delaware River at the Delaware Water Gap and has an altitude of only about 280 feet. The local relief varies in the different counties, and is described separately for each county.

DRAINAGE

The greater part of the area covered by this investigation is drained by the Susquehanna River and its tributaries, chiefly by the North Branch but in Northumberland County by the West Branch. The eastern part of the area, comprising nearly all of Wayne County, all

of Pike County, and about two-thirds of Monroe County, is drained by the Delaware River. Nearly all of Carbon County and portions of Monroe, Lackawanna, Luzerne, and Schuylkill Counties are drained by the Lehigh River, a tributary of the Delaware River. The greater part of Schuylkill County and a very small part of Carbon County are drained by the Schuylkill River, also a tributary of the Delaware. In flowing from Pittston, Luzerne County, to Rockville, Dauphin County, a distance of 116 miles, the Susquehanna River drops 234 feet, having thus an average gradient of about 2 feet to the mile.

PHYSICAL DIVISIONS

The physical divisions represented in Pennsylvania are shown in figure 2. The area described in this report lies within the Appalachian

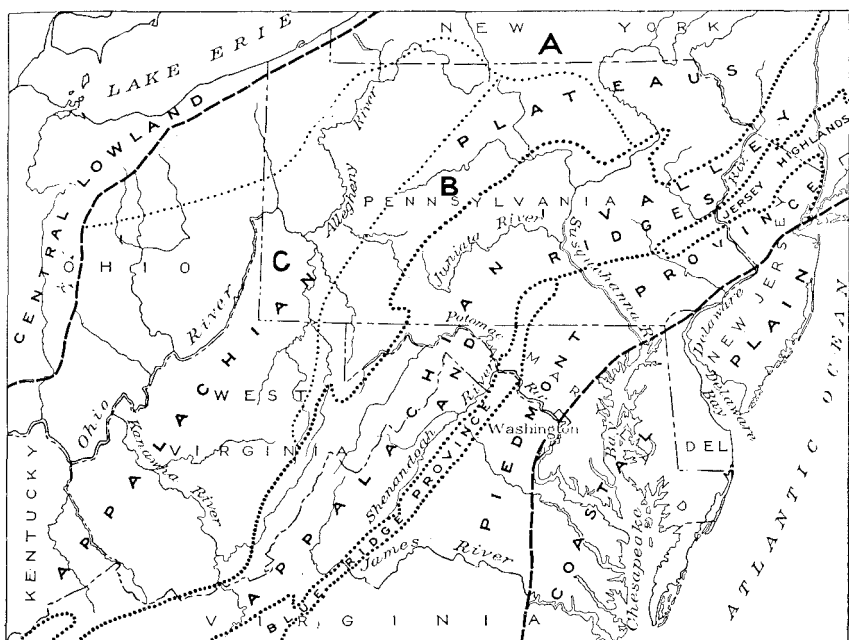


Fig. 2. Map of Pennsylvania and parts of adjoining States showing the major physical divisions. Subdivisions of the Appalachian Plateaus province: A, Allegheny Mountain section; B, Southern New York section; C, Kanawha section

Plateaus province and the Valley and Ridge province, subdivisions of the Appalachian Highlands. The northern part of the area is in the Appalachian Plateaus province, a mature glaciated plateau of moderate relief, in which the rock strata are nearly horizontal over large areas. The southern and larger part of the area lies in the Valley and Ridge province, where the rocks have been strongly folded and then planed down by erosion.

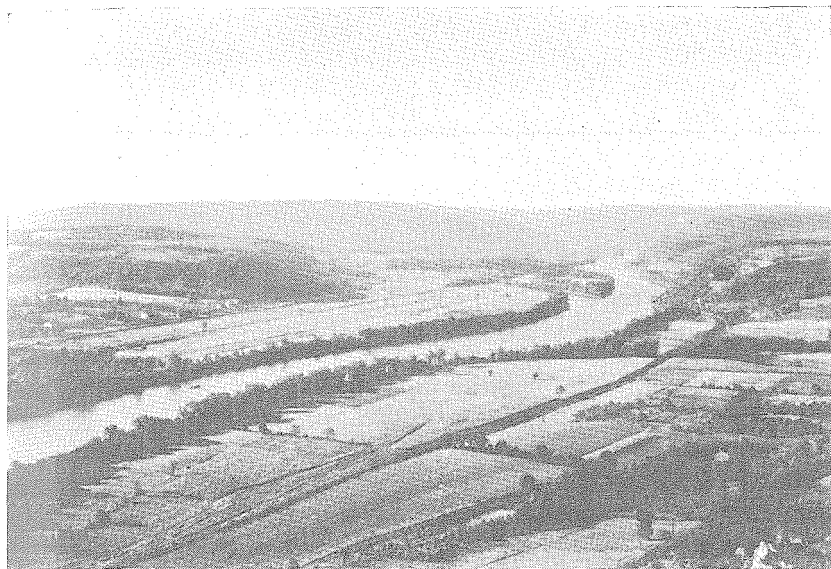
Appalachian Plateaus province.—Susquehanna, Wayne, Wyoming, and Pike Counties and parts of Lackawanna, Luzerne, and Monroe Counties

lie in the Appalachian Plateaus province. Here the rock strata are nearly horizontal in most places, except for a few minor folds. The geomorphic evidence leads to the belief that the region has been base-leveled and, in common with the Valley and Ridge province, reduced to a well-defined peneplain. The entire region was then elevated, and the streams, thus given new energy, have eroded the surface of the plain so that it now presents the appearance of a very hilly country. However, evidences of the former plain are seen in the remaining hilltops, which stand at approximately even heights in many places. The line between the Appalachian Plateaus and the Valley and Ridge province is readily apparent, for there the dip of the strata changes from 0° - 5° to 30° - 60° and strike ridges composed of hard sandstones make their appearance.

Valley and Ridge province.—The Valley and Ridge province includes most of the counties in the area and extends as far north as Forest City. In the northern part of the area there are innumerable ridges and valleys trending generally northeast and curving gently toward the north. Geologically this is a region of alternating hard and soft sedimentary rocks, which have been bent by lateral compression from the southeast into folds or waves—anticlines (arches) and synclines (troughs). After the rocks had been folded the whole area was slowly baseleveled by erosion, and hard and soft layers alike were finally reduced to a nearly uniform surface. Then a general uplift of the region gave the streams renewed vigor and began another period of erosion, which is still operating at the present time. During this last cycle of erosion the softer rocks have been gradually worn down and carried away and the more resistant rocks stand out as ridges, as shown in plate 2-A. The effect of the pitch of the folds has had a marked influence on the present-day topography and has resulted in a series of canoe-shaped synclinal valleys in which are located the principal anthracite fields.

The southern border of the area is Kittatinney Mountain, extending from Delaware Water Gap nearly to the Maryland line. It is also known as Blue, North or First Mountain southwest of Wind Gap. This ridge is also the southern border of the Valley and Ridge province. South of this border is the Lebanon Valley, continuous with the Cumberland Valley of Pennsylvania farther west and the Shenandoah Valley of Virginia. The contrast between the Valley and Ridge province and the Lebanon Valley is very striking.

Plate 3



A. Susquehanna River Valley looking northwest toward Shickshinny from Council Cup, Wapwallopen, Luzerne County



Photo by G. H. Ashley

B. Unconformable contact of Tuscarora sandstone (at right) and Martinsburg shale (at left) exposed on eastern cut on Reading Railroad along west side of Schuylkill River below Port Clinton, Schuylkill County

GEOLOGY

OUTLINE OF STRATIGRAPHY

Unconsolidated deposits.—Recent alluvium is found along the rivers and streams and is described on a subsequent page.

Glacial drift of at least three of the Pleistocene glacial stages is found over more than half of the area described in this report. The drift borders are shown on plate 1, and the general features and ground-water conditions of the deposits are described in a general way on pages 41-44 and for each county in the county descriptions.

Rock formations.—The rock formations in the area are all of sedimentary origin, are all of Paleozoic age, and belong to the Carboniferous, Devonian, and Silurian systems, with locally one formation of the Ordovician system. They range in age from the post-Pottsville formations of the Pennsylvanian series (youngest) down to the Juniata formation, of Upper Ordovician age² (oldest). The areal distribution of these formations is shown on plate 1, and regional descriptions of the formations and the occurrence of ground water in them are given on subsequent pages. The thickness and character of the rocks underlying the different counties, together with more detailed information as to their local ground-water conditions, are given in the county descriptions. The rock formations are described in descending order, beginning with the youngest, as this is the order in which well drillers are accustomed to think of them.

STRUCTURE

The geologic structure of the rock formations exposed in the area dates back to the Appalachian revolution. In the Valley and Ridge province the rocks are folded into numerous anticlines and synclines, with the youngest formations in the synclines and the oldest formations cropping out in the anticlines. The valuable anthracite beds were preserved from extensive erosion in the deep synclinal basins. The folds do not continue indefinitely in both directions along their axes but pitch downward in many places, which has resulted in a series of canoe-shaped synclines. Many of the coal basins are not simple synclines but contain numerous minor folds and faults.

In the Appalachian Plateaus province the rocks are still horizontal in most places, with only a few minor folds or rolls, generally of local extent. The rocks in this province were not greatly affected by the Appalachian revolution and were able to maintain essentially the same position in which they were deposited, except that they were elevated bodily above sea level.

The structure of the area differs considerably among the several

² The Pennsylvania Topographic and Geologic Survey classes the Juniata as Silurian.

counties, and for this reason all the structural details, including the names, trends, and locations of the folds, dips of the rocks, and local occurrences of faults are described separately for each county.

GEOLOGIC HISTORY AND GEOMORPHOLOGY

The geologic history of the area begins with the folding of the rocks which are older than those exposed but which underlie the area at great depth. These rocks comprise shales, limestones, sandstones, and quartzites of the Ordovician and Cambrian systems and the underlying pre-Cambrian rocks. In late Ordovician time these rocks were raised and folded during a disturbance known as the "Taconic disturbance." After a period of erosion, during which the softer rocks in this area were reduced to a low level, the area gradually subsided again below sea level, and the deposition of the Silurian rocks began. The unconformity between the basal Silurian and the underlying Ordovician rocks is well shown at the Schuylkill Water Gap, where the coarse massive Silurian Tuscarora sandstone overlies the Ordovician Martinsburg shale with an angular discordance of about 90°. (See pp. 67, 68 and pl. 3-B). During the deposition of the Silurian and Devonian strata continual changes in climatic conditions and oscillations in sea level produced sediments of varying composition, color, and texture, such as conglomerate, sandstone, shale, and limestone. Then followed the deposits of the Carboniferous period, during which the land probably oscillated slightly above and below sea level numerous times. Innumerable plant remains collected in swamps, became entombed between layers of silt or sand, and by later compaction were changed to coal.

At the end of Paleozoic deposition a great thickness of sediments had accumulated in the subsiding shallow seas. Then a great horizontal pressure in the earth's crust began acting from the southeast, compressing and folding the rocks and shortening a portion of the crust by many miles. The vast accumulation of horizontal sediments was folded, much like a pile of rugs folded by lateral pressure, into steep anticlines and synclines, which trend northeast, at right angles to the direction of the crustal force. In some places the compression was great enough to overturn the folds, so that older rocks lay on top of younger rocks. This great period of folding and mountain making, known as the "Appalachian revolution," did not affect the entire region equally but folded the rocks intensely only in the area lying southeast of the Appalachian Plateaus. In the plateau country the strata are only gently folded or still lie nearly horizontal. The heat and pressure involved in the severe folding and faulting of the coal beds in the Carboniferous rocks in the anthracite field resulted in the escape of nearly all of the volatile constituents and produced the well-known anthracite, or hard coal. The folding probably took place very slowly, so that erosion cut down the high

folds as they rose and kept them from reaching their possible maximum height. Nevertheless, at the end of the Appalachian revolution the Appalachian Mountains possibly rivaled the Alps in height and grandeur.

The Appalachian revolution, terminating the deposition of Paleozoic sediments, was the last period of folding that noticeably affected the area described in this report. Then followed a long period of erosion during the Mesozoic era, when the mountains were worn down and some of the material, largely mud and sand, was carried into depressed areas southeast of the present mountains, forming the Triassic red beds. During this time the rocks were broken by great faults, and while the crustal blocks were rising and sinking in southeastern Pennsylvania considerable igneous material was intruded into the rocks and some was extruded on the surface as lava, but this disturbance did not noticeably affect north-eastern Pennsylvania.

Aside from the Triassic deposits just mentioned, there is little record of events in Pennsylvania during Mesozoic and most of Tertiary time. Erosion was active, the material going to form the Mesozoic and Tertiary deposits of New Jersey. These deposits may have overlapped eastern Pennsylvania.³ The land remained nearly stationary for a long time, until eventually even the hills composed of the harder rocks were worn down and the greater part of the region was reduced to a rolling plain that stood not far above sea level and sloped gently toward the sea. This old land surface has been called the "Schooley peneplain," and remnants of it are still reflected in the even crests of ridges such as Kittatinny or Blue Mountain, which now stands at an altitude of about 1,600 feet.

Later the land was once more elevated, and a new period of erosion began. Much of that part of the surface of the old plain that was composed of softer rocks was cut away, but the harder rocks, such as those forming the top of Kittatinny Mountain, were left in bold relief, as shown in plate 2-A. There may have been halts in the uplift of the land to its present position, which may have left records in the form of benches and hilltops. A peneplain formed during one of the longer pauses in the uplift, probably in late Tertiary time, is called the Harrisburg peneplain, from the city of Harrisburg, where it is noticeably prominent. Since the Harrisburg peneplain was formed the region has been raised to its present position by a series of uplifts and has been carved by streams into terraces, hills, and valleys.

³ Davis, W. M., The rivers and valleys of Pennsylvania: *Nat. Geog. Mag.*, vol. 1, pp. 184-253, 1889. Campbell, M. R., Geographic development of northern Pennsylvania and southern New York: *Geol. Soc. America Bull.*, vol. 14, pp. 283-284, 1903. Knopf, E. B., Correlation of residual erosion surfaces in the eastern Appalachian Highlands: *Idem*, vol. 35, pp. 633-668, 1924. Stose, G. W., Possible post-Cretaceous faulting in the Appalachians: *Idem*, vol. 38, pp. 498-505, 1927. Johnson, Douglas, Stream sculpture on the Atlantic slope, a study in the evolution of the Appalachian rivers: 142 pp., ill., New York, Columbia Univ. Press, 1931. Ashley, G. H., Studies in Appalachian Mountain sculpture: *Geol. Soc. America, Bull.*, vol. 46, pp. 1395-1436, pls. 119-126, 14 figs, Sept. 30, 1935.

At the beginning of the Quaternary period the climate became cold and moist, and an immense blanket of snow accumulated to the north and consolidated into a great glacier that spread over much of the area. In many places there are rock surfaces smoothed and polished by the ice sheet as it slowly moved across the area from the north. Later, when the climate became warmer, the ice sheet melted away and left over most of the area a layer of gravelly clay, called "till," and the valleys became filled with sand, gravel, and silt brought down by the streams that issued from the melting ice. Still later the streams cut new and deeper channels into these deposits, leaving broad terraces such as now border the Susquehanna and Delaware Rivers in many places (pl. 2-B). The deposits left in this manner show that there were at least three periods of invasion by glaciers, interrupted by warmer periods, and the last advance covered only about half of the area. Since the last retreat of the ice the streams have altered the land into its present form.

GROUND WATER

SOURCE

The ground water, or underground water, is the water that issues from springs or can be pumped from wells. It is derived from precipitation in the form of rain or snow. In some parts of the United States, the water obtained from wells has traveled many miles from the area of intake, but in northeastern Pennsylvania the water obtained from shallow dug wells and springs is generally derived from precipitation in the immediate vicinity, and the water obtained from the deeper drilled wells is derived from precipitation in the general vicinity, usually within the same or an adjacent county.

Many of the residents of this area fallaciously attribute the source of the water in their springs or wells to far distant lakes or rivers. For example, between Frackville and Fountain Springs, in Schuylkill County, some of the well owners believe that the water in their wells comes from Lake Seneca, in the State of New York, despite the fact that the surface of the lake is only about 440 feet above sea level, whereas Frackville and Fountain Springs are respectively 1,500 and 1,000 feet above sea level. Others believe that the ground water comes from nearby lakes or rivers, but in a humid region, such as northeastern Pennsylvania, the lakes and rivers generally do not lose water into the ground and almost invariably receive water from the ground, so that the water level in nearby wells stands somewhat above the water level of the stream or lake.

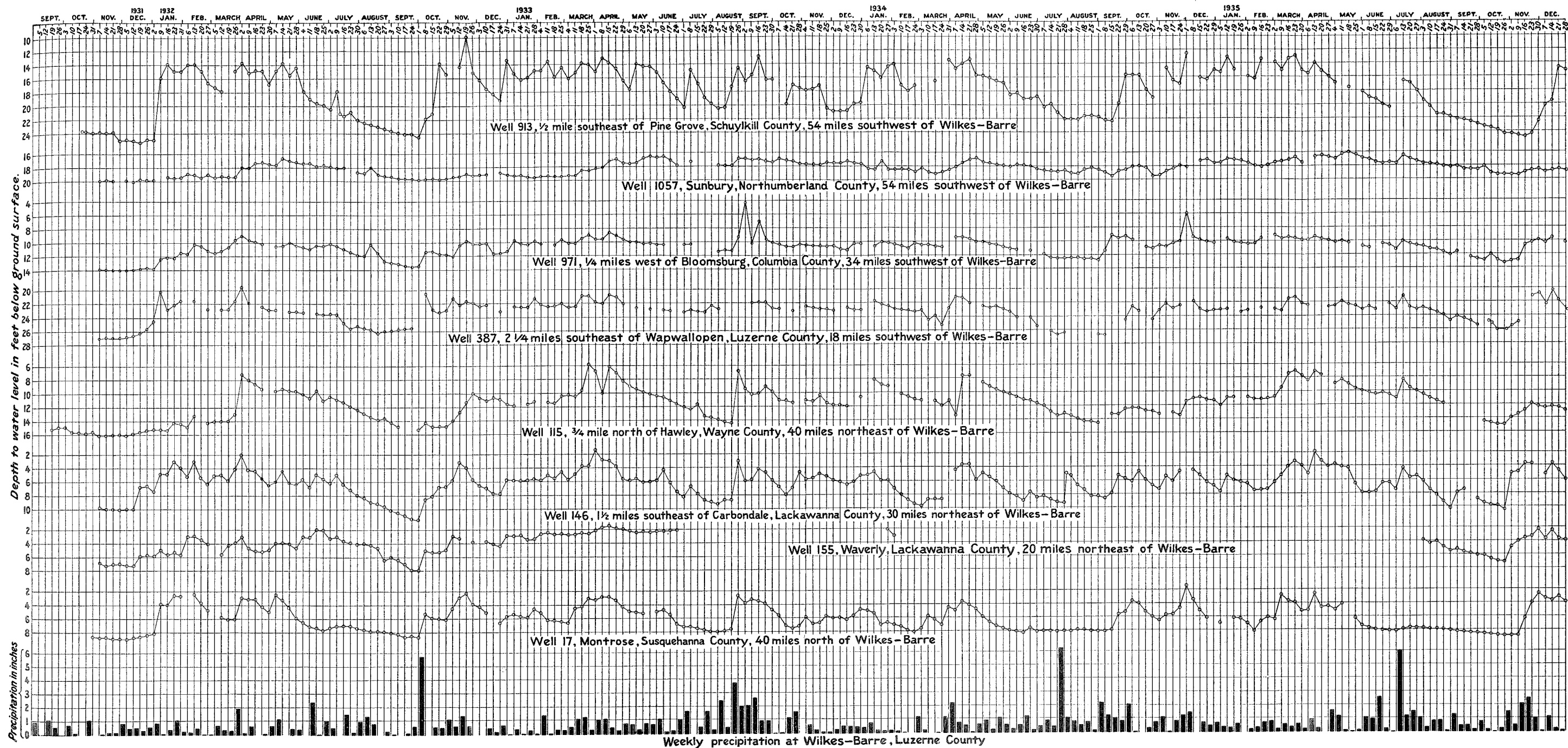
Some of the residents in the area do not believe that the amount of water falling as rain or snow is sufficient to supply the large under-

ground reservoirs. However, 1 inch of water falling on 1 square mile amounts to more than 15,000,000 gallons, and the average annual precipitation in northeastern Pennsylvania is 43.67 inches, or about 660,000,000 gallons to the square mile. Part of this water is carried directly to the sea through the surface streams, part is evaporated directly into the air, part is transpired by plants, and the remainder sinks through the ground to the water table and becomes available to the wells and to the springs that supply the streams and lakes with water during dry periods.

There is a relation between the amount of water falling as rain or snow and the level at which the water stands in wells, but the relation is complicated by several factors. Other things being equal, the greater the precipitation for a given period the greater the rise in the water level. However, after a prolonged dry spell the water contained in the soil becomes depleted, and when rain occurs, it must first replenish the soil moisture before any of the water can percolate down to what is called the "water table," or the upper surface of the zone of saturation. The temperature also has a decided influence, for rain that falls on frozen ground is greatly hindered from reaching the water table, and part of the water falling during the hot summer is evaporated directly into the air. With the coming of spring the vegetation begins to make heavy demands on the soil moisture, and in some places where tree roots extend down to the water table the trees draw water directly from the zone of saturation. Thus, although the rainfall is greater during the summer, the water table generally declines, owing to the heavy consumption of water by the vegetation. When the first killing frost occurs in the fall, consumption of water by vegetation ceases, and even though there may be no appreciable precipitation, the water level in wells on lowlands may rise somewhat and small springs may increase in flow. During the winter, at times when the ground is not frozen, the precipitation can percolate downward with little loss from evaporation or transpiration, and when the soil moisture has been replenished, a moderate amount of precipitation may cause an appreciable rise in the water table. The fluctuations of the water table are also dependent upon other factors, including the type of water-bearing material, topography, and depth to water. There is also a relation between the height of the water table and the low flow of the streams which is largely ground water.

In order to study the relation between water-table fluctuations and the various factors mentioned above, the writer⁴ selected during the fall of 1931 thirty-six observation wells widely spaced over the entire State of Pennsylvania. Most of these are unused shallow dug wells but a few are drilled. The depths to water level in these wells are measured weekly to the nearest 0.01 foot by local observers. The weekly fluctu-

⁴ Lohman, S. W., Investigations of the fluctuations of the ground-water table in Pennsylvania: National Research Council, Am. Geophysical Union, Trans. of 13th Ann. Meeting, pp. 373-375, June, 1932.



Graph showing the weekly fluctuations of the water levels in 8 observation wells in northeastern Pennsylvania and the weekly precipitation at Wilkes-Barre

ations of the water table in eight of these wells that are located within the area embraced by this report are shown in plate 4.

Plate 4 shows that individual wells react quite differently to precipitation during the winter owing to differences in depth to water and in local conditions, yet they behave rather uniformly during periods of low water table such as the months of November 1931 and September 1932. The normal summer declines in 1932 and 1933 were arrested sharply by heavy rains in October 1932 and September 1933, and the water levels rose abruptly. Similar but less widespread rains in July 1934 and July 1935 produced pronounced rises of water level in some of the wells but others, such as well 17, received much less rain and therefore the water levels in these wells showed little or no gain on those dates.

Wells situated in material of rather low permeability, such as well 913, show rises in water level of several feet in response to precipitation whereas a similar amount of rain may raise the water level only slightly in wells that are situated in fairly permeable material, such as well 1057. Moreover, well 1057 is located close to and but slightly above the Susquehanna River so that the water level in the well is governed somewhat by the height of the water in the river. Most of the other wells are situated on slopes or hillsides and are not affected directly by the height of the water in nearby streams.

The beginning of recharge for the winter of 1931-32 is shown by a rapid rise in most of the wells during the first week in January. The beginning of recharge for the following three winters was somewhat obscured by the heavy fall rains described above, but appears to have been in December for the winters of 1932-33 and 1933-34 and in September for the winter of 1934-35.

The direct comparison of weekly water-level fluctuations with weekly precipitation shown on plate 4 has been shown above to bring out certain interesting relationships. However, there are definite seasonal fluctuations produced by factors other than precipitation that often make it difficult to correlate water-level fluctuations directly with precipitation. That is, the water levels generally stand highest in April and lowest during the fall, whereas the precipitation is greatest in July and August and smallest in the winter. Moreover, the 8 wells are situated from 18 to 54 miles from Wilkes-Barre, the central point for which the precipitation is plotted on plate 4, and the precipitation varies considerably over such distances. Therefore, in order to show more correctly the relationship between fluctuations of the water level in wells and the precipitation, the seasonal fluctuations of both the water levels and the precipitation must be eliminated and the observation well must be situated close to the rain gage. An attempt has been made to do this in figure 3.

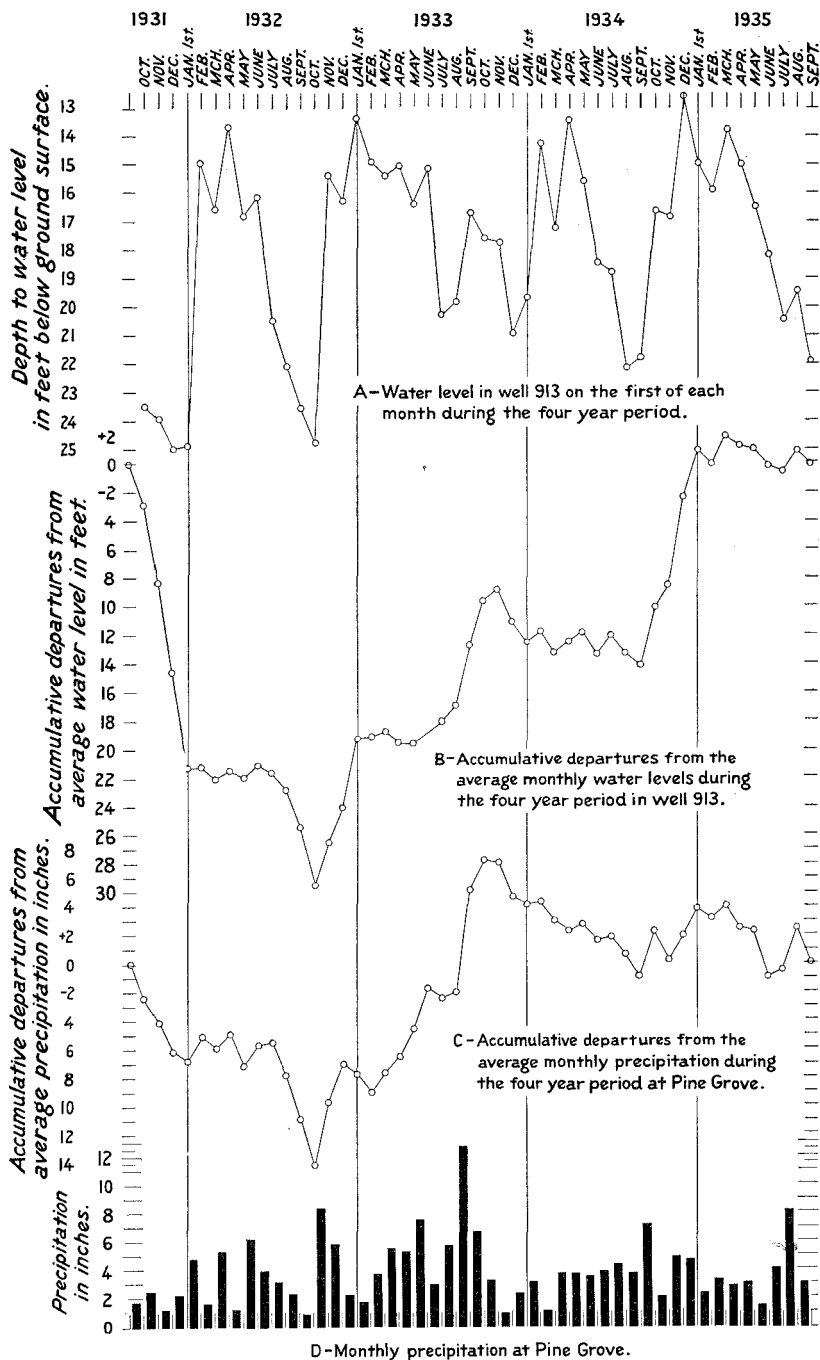


Figure 3. Graphs showing the relation between the monthly fluctuations of the water level in well 913, $\frac{1}{2}$ mile southeast of Pine Grove, Schuylkill County, and the monthly precipitation at Pine Grove. Precipitation data from U. S. Weather Bureau

The method of correlating water-level fluctuations with precipitation shown in figure 3 was worked out first by Wenzel.⁵ Well 913 was selected because it is only $\frac{1}{2}$ mile from the Weather Bureau's station at Pine Grove. Figure 3, A, shows the water levels on the first of each month for the 4-year period from October 1, 1931, to September 1, 1935, and D shows the monthly precipitation for the same period. In curve B the seasonal fluctuations of water-level have been eliminated and in curve C the seasonal fluctuations in precipitation have been eliminated. Curve B was obtained by first determining the average monthly water levels for each month during the 4-year period, then determining the departures from the average monthly water levels, and finally by the addition of the departures from average to give the accumulative departures from the average monthly water levels. An upward trend on this curve indicates above-average water levels and a downward trend indicates below-average water levels. Curve C was obtained in the same manner using the monthly precipitation at Pine Grove for the same 4-year period.

A comparison of curves B and C indicates rather conclusively that the amount of precipitation is the dominant factor that controls the fluctuations of water level in the observation well. However, there are a few points on these curves which at first glance seem to show a negative correlation, but these discrepancies are explicable. During June 1932 the precipitation rose somewhat above normal, as indicated by a slight upward trend on curve C, yet the water level declined somewhat. This is to be expected because the heavy withdrawals of water by evaporation and transpiration during June produces such a marked downward trend that heavy precipitation would be necessary even to keep the water levels stationary and considerably above average precipitation would be necessary to raise the water level. In December 1932 the water levels rose considerably above normal yet the precipitation was below normal, but during the winter when transpiration had ceased, conditions are so ideal for recharge that even very slight precipitation may raise the water level. The discrepancies between curves B and C during October 1933 and October 1934 are due to the fact that the water levels were raised so abnormally high by heavy precipitation during September of those two years that despite actual slight declines in water levels during October the water levels still remained above average on November 1 of each year. The discrepancy during June 1935 is similar to that for June 1932.

The flow of many springs also fluctuates with the precipitation and other climatic conditions. The flows of several small springs in Susquehanna County were measured and remeasured during wet and dry

⁵ Wenzel, L. K., Methods of studying water-level fluctuations (unpublished report in files of U. S. Geol. Survey, 1935).

periods and showed considerable variation in yield. The results of these measurements are described on page 264.

OCCURRENCE ⁶

GENERAL FEATURES

The rocks forming the outer crust of the earth are in general not entirely solid but contain numerous open spaces, called "voids" or "interstices," which may contain either liquid or gas, such as water, oil, natural gas, or air. There are many kinds of rocks, and they differ in the number, size, shape, and arrangement of their interstices and hence in the amount of water they are able to hold. The occurrence of ground water in any region is therefore determined by the geology of the region.

The interstices in rocks range from microscopic openings to the large caverns found in limestone regions and may be classified, according to their origin, into primary and secondary interstices. The primary or original interstices were formed when the rock itself was formed, the secondary interstices were developed by processes that affected the rock after it had been formed. In northeastern Pennsylvania all the rocks are of sedimentary origin, and the openings that contain water are of three kinds—(1) the pore spaces between the grains of the rock, (2) the joints, crevices, and open bedding planes that have resulted from fracturing of the rocks, and (3) solution cavities in limestone, which have resulted from solution of the rock by water moving along the joints or bedding planes.

POROSITY

The amount of water that can be stored in any rock depends on the porosity of the rock, which is commonly expressed as the percentage of the total volume of the rock that is occupied by interstices. A rock is said to be saturated when all its interstices are filled with water, and its content of water is equal to the porosity. As stated by Meinzer,⁷

The porosity of a sedimentary deposit depends chiefly on (1) the shape and arrangement of its constituent particles, (2) the degree of assortment of its particles, (3) the cementation and compacting to which it has been subjected since its deposition, (4) the removal of mineral matter through solution by percolating waters, and (5) the fracturing of the rock, resulting in joints and other openings.

Well-sorted deposits of uncemented gravel, sand, or silt have a high porosity, regardless of the size of the individual particles, but in poorly sorted material in which small particles fill the spaces between the larger

⁶ For a more detailed treatment of the general subject of the occurrence of ground water, see Meinzer, O. E., *The occurrence of ground water in the United States with a discussion of principles*: U. S. Geol. Survey Water-Supply Paper 489, 1923.

⁷ Meinzer, O. E., *op. cit.*, p. 3.

ones the porosity is reduced considerably. In either sorted or unsorted material the porosity may be greatly reduced if the interstices are partly filled with some cementing material, such as calcium carbonate (CaCO_3), silica (SiO_2), or iron oxide (Fe_2O_3).

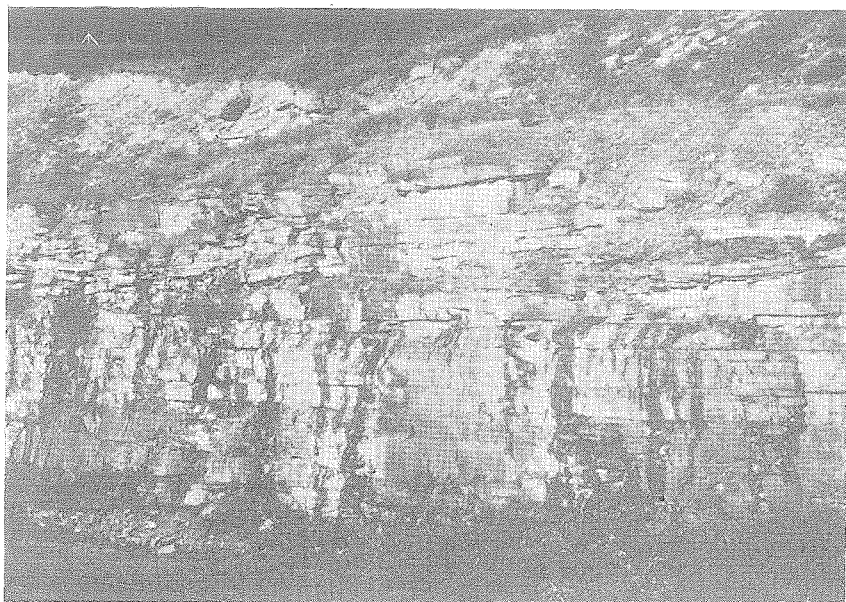
Porosity alone determines only how much water a given rock can hold, not how much it can yield to wells. For example, a well-sorted silt may have a higher porosity than a coarse, poorly sorted gravel and consequently may hold more water. However, not all the water in a saturated rock is available to wells, because part of the water is held against the force of gravity by molecular attraction. In a fine-grained rock the molecular attraction is very great, and only a small part of the water can be drained out by the force of gravity, whereas in a coarse sand or gravel having the same porosity only a small part is retained by molecular attraction and the remainder, acted on by gravity, becomes available to wells. Thus for a given porosity and a given degree of assortment, a coarse-grained rock will yield more water to wells than a fine-grained rock.

Many rocks that have very low porosity contain considerable water in secondary openings, such as joints, crevices, or solution cavities. Hard, well-cemented sandstones or shales of very low porosity may yield considerable water from joints or fractures. Hard, brittle rocks are fractured by earth stresses, and the resulting joints commonly occur in parallel sets, and two or more sets of joints may intersect. Joints near the surface are in general sufficiently open to allow movement of the water, but with increased depth the walls are closer together, and at great depth the joints are generally tightly closed. In sedimentary rocks one set of joints is commonly parallel to the original bedding planes of the rock. Plate 5-A shows water seeping from fractures along bedding planes in a hard well-cemented sandstone, and other types of joints are shown in plates 7-A, and 5-B. Such openings in hard rocks are of considerable importance as conduits of ground water in northeastern Pennsylvania.

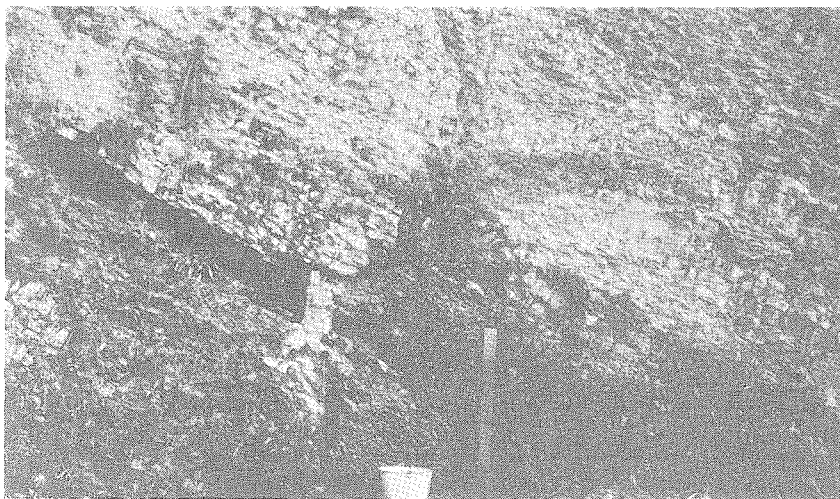
Limestone may have only low porosity, but, being hard and brittle, it develops joints and fractures, and the movement of water through these secondary openings may dissolve out parts of the rock, leaving large solution cavities or large caverns. Such openings may yield very large amounts of water.

PERMEABILITY

The permeability of a rock may be defined as its capacity for transmitting water under pressure and is measured by the rate at which it will transmit water through a given cross section under a given pressure per unit of distance. As explained in a previous paragraph, a bed of silt or clay may have as high a porosity as a deposit of coarse sand or



A. Water seeping from bedding planes in a sandstone of the New Milford formation, in a railroad cut at Hopbottom, Susquehanna County



B. Water seeping from bedding planes and fractures in thin-bedded sandstone of the Portage group, one mile southeast of Danville, Montour County

gravel, but because of the small size of its interstices it may require the application of a great pressure to transmit water, and hence, under the incompetent force of gravity, it may be entirely impermeable. Thus a well may be put down into rock which, though saturated with water, will yield almost no water because of its low permeability. On the other hand, a well put down into coarse gravel or sand with a high permeability may yield a very large supply of water.

The permeable rocks that lie below a certain level in northeastern Pennsylvania are generally saturated with water. These saturated rocks are said to be in the zone of saturation, and the upper surface of the zone of saturation where it is overlain by unsaturated permeable material is called the "water table." Where the upper surface is formed by impermeable rock that confines the water in the zone of saturation under pressure, there is no water table, and the imaginary surface to which the water rises under its full head is called the "piezometric surface." The permeable rocks lying above the zone of saturation are referred by Meinzer⁸ to the zone of aeration. The water that falls on the soil is slowly drawn down by gravity through the zone of aeration to the zone of saturation, except that which is held in the zone of aeration by molecular attraction. In fine-grained material the earth is always moist several feet above the water table, owing to capillarity, and this moist belt is called the capillary fringe. The water retained by capillarity is not available to wells, and wells must be sunk to the water table before water enters them.

Where permeable rock is homogeneous down to a considerable depth, there is only one zone of saturation, but in some localities the water may be hindered in its downward course by a relatively impermeable bed and form an upper zone of saturation. Such a body of water is called a "perched water body" and has a perched water table that is independent of the main water table.

In northeastern Pennsylvania the water table is an undulating surface which generally stands higher beneath upland areas than beneath the adjacent valley areas and slopes gradually down to the level of the streams or lakes. As the ground water is under hydrostatic pressure, the slope of the water table toward the streams or lakes shows that the movement of ground water is toward the streams or lakes, so that, except at flood stages, these bodies of water are commonly gaining water from the zone of saturation, and not losing it into the ground.

A depression in the land surface that intersects the water table may produce springs, known as "depression springs." Small springs of this kind are numerous in many parts of northeastern Pennsylvania. A bed of clay or other impermeable obstruction may prevent the water from

⁸ Meinzer, O. E., *op. cit.*, p. 29.

moving downward and may cause it to seep out at the surface where the bed crops out, as in the sides of a valley, producing "contact springs."

RELATION TO GEOLOGIC STRUCTURE

In many of the rock formations in northeastern Pennsylvania strata of hard sandstone that are rendered permeable by the presence of numerous joints alternate with strata of impermeable or nearly impermeable shale. In places where the strata are tilted, water falling on the outcrop area of a permeable stratum moves down the dip between the confining walls of impermeable shale and saturates the permeable stratum nearly to the surface. Under these conditions wells drilled through the overlying shale into the water-bearing bed generally encounter water under pressure that will raise it in the well to some point above the level at which it was struck. If the well is on considerably lower land than the outcrop of the water-bearing bed, the water may rise to the surface and flow over the top of the casing. If the water level in such a well stands higher than the local water table, the well is an artesian well, and if the water flows at the surface it is a flowing artesian well. Areas where the water is under artesian pressure are said to have "artesian conditions"; where it is not, "water-table conditions."

In many places in northeastern Pennsylvania the structure of the rocks is favorable for artesian wells, and in some places flowing wells are obtained. Particularly favorable conditions are found on the structural features known as "monoclines," where the strata all dip in one direction, and on synclines, where the strata on all sides dip toward a common axis or center. In northeastern Pennsylvania the most favorable artesian conditions are found in the large canoe-shaped synclines or elongated basins, although flowing wells occur locally in a few places where the strata are nearly horizontal. In Monroe County a few flowing wells obtain water from glacial drift, in places where beds of permeable gravel are overlain by relatively impermeable clay or "hardpan."

Where the confining beds are fractured or otherwise rendered slightly permeable, water may escape from the artesian reservoir and may rise to the surface and form springs.

The occurrence of flowing wells and the locations of areas where flowing wells might be expected are discussed in the county descriptions.

WATER IN GLACIAL DRIFT

Till, or boulder clay, which is the unstratified material dropped directly by the ice sheet, is unsorted and therefore generally does not yield water very freely, but its yield varies according as it is composed chiefly of coarse or fine material. Till and associated lenses of sand or gravel supply nearly all the dug wells in northeastern Pennsylvania north of the Wisconsin drift border (pl. 1). The yields of these wells are gen-

cally small but adequate for domestic use. Dug wells generally extend only a short depth below the water table, and therefore they are more dependent on frequent recharge from precipitation than the deeper drilled wells and are likely to fail during periods of dry weather. They are also subject to contamination from nearby barnyards and privies. (See p. 40.)

Glacial outwash has been sorted by running water, so that the fine and coarse materials have been separated and occur in irregular lenses of clay, sand, quicksand, and gravel. This sorting action has produced deposits of high porosity and, in the coarser material, high permeability. In northeastern Pennsylvania small deposits of stratified drift occur in many places intermingled with deposits of till and supply many dug and driven wells and a few drilled wells. The most extensive deposits of glacial outwash, however, occur along the valleys of the Susquehanna and Delaware Rivers and some of their large tributaries.

As shown in figure 4, the outwash generally consists of irregular lenses of clay, sand, quicksand, and gravel. The clay and quicksand may contain considerable water, but the clay does not yield water freely to wells, and the water-bearing quicksand flows bodily into wells and is therefore to be avoided as a source of ground water. The coarser sand and the gravel yield water freely, and very large quantities of water are obtainable from them in many places by means of properly constructed drilled wells employing well screens.

In northeastern Pennsylvania a few driven wells and drilled wells obtain water from glacial outwash sand and gravel. As a rule, the drilled wells have casings open at the bottom but not perforated or equipped with screens. Very few drilled wells are properly constructed to obtain large yields of water from the unconsolidated deposits. The proper method of recovery of water from outwash gravel is described on pages 33-35.

One of the most important facts brought out by this investigation is that the possibilities of obtaining large supplies of water from outwash sand and gravel have been largely ignored in northeastern Pennsylvania. In innumerable wells from 50 to 150 feet of water-bearing sand and gravel has been cased off, the casings have been driven tightly into the bedrock, and the holes have been continued deep into the bedrock. In many wells the supply from the bedrock is far less than that which could be obtained by properly developing the water in the glacial drift. It is true, of course, that in certain localities drift water is subject to pollution, but in most places the drift water is of good sanitary quality.

By far the strongest wells in northeastern Pennsylvania are the three drilled wells of the Stanton Operating Co. at Harding, Exeter Township, Luzerne County, which obtain water from glacial outwash. (See well 294, p. 148 and fig. 11, also pp. 33-35 and fig. 5.)

WATER IN SANDSTONE AND CONGLOMERATE

Most of the drilled wells in northeastern Pennsylvania obtain water from sandstone, and some of them obtain water from conglomerate. Many of the wells reported to end in shale are believed to end in sandy shale or sandstone, but in some wells the nature of the water-bearing material is not known, because of inadequate records.

Beds of sandstone and, to a lesser degree, of conglomerate are numerous in most of the rock formations exposed in northeastern Pennsylvania, and one or more such beds can generally be reached by wells of moderate depth. The size of grain, degree of assortment, amount of cementation, and the amount of jointing are the principal factors that determine the water-bearing properties of a sandstone or conglomerate. With few exceptions, all the sandstones and conglomerates appear to be firmly cemented, so that their porosity is probably rather low. The Oriskany sandstone appears to be rather porous, but, as pointed out in the descriptions of the counties in which the Oriskany occurs, it is relatively unimportant as a source of ground water, owing to the fact that its outcrops are hilly, wooded, and generally devoid of habitation. Most of the sandstones are well jointed and fractured along bedding planes, so that although in some of them the permeability is doubtless due to the porous texture, it is generally due to joints, or to a combination of these two factors. Although the cementing material (chiefly silica, SiO_2) greatly reduces the porosity, it makes the rock hard and brittle, so that numerous joints may develop, and also prevents loose sand grains from entering the well. In this way cementation may indirectly produce better water-bearing conditions.

The stronger wells in the area obtain water from outwash gravel, but the greatest aggregate amount of ground water is probably derived from sandstones.

WATER IN SHALE

Some wells in northeastern Pennsylvania end in shale, which is locally often called "slate" or "shell." Although much of the shale has considerable porosity, the pore spaces are so small that most of the water is retained in the rock and does not become available to wells. In most places, however, the shale is broken by joints and bedding planes, along which water moves. As a rule the shales will supply enough water for domestic purposes and in some places sufficient water is obtained for industrial use, but here again sandy shale or thin beds of sandstones may contribute most of the water.

WATER IN LIMESTONE

Limestone is relatively of little value as a water-bearing formation in most of northeastern Pennsylvania, because of its slight areal extent and

narrow outcrops and because of the uncertainty of obtaining an adequate supply from it. Water in limestone occurs chiefly in solution channels. If one or more solution channels containing water are encountered in drilling, the well is likely to be fairly strong. If, however, no solution channels are encountered, a weak well or even a dry hole may result. There are a few strong wells ending in limestone in northeastern Pennsylvania, and there are some dry holes. In many places the limestone contains balls of chert or "niggerheads," which often cause serious trouble in drilling. Limestone beds dipping at a low angle underlie large areas in Northumberland County and supply hard water to numerous domestic and industrial ground-water users. (See section on Montour and Northumberland Counties.)

WATER IN COAL

The numerous beds of coal in the post-Pottsville Carboniferous formations are generally well fractured and contain considerable water. This water, together with the water contained in the sandstone encountered in mining, must be pumped or drained from the coal mines and is used for washing coal. The water in the coal is in general highly mineralized and is not known to be usable for any other purpose. The oxidation of pyrite yields acidic waters, most of which contain considerable iron. In the few wells known to penetrate coal beds the casings were extended some distance below the lowest coal bed, in order to insure a potable water supply.

RECOVERY^a

In northeastern Pennsylvania ground water is recovered chiefly by means of dug and drilled wells, but driven wells are in use in a few localities where the water table lies close to the surface. Water is also recovered in some places from diamond-drill holes of small bore and from abandoned ore tunnels or infiltration tunnels. In many parts of the area, particularly in the glaciated region, springs are utilized not only for domestic supplies but also for industrial and municipal supplies. Although the quantity of water obtained from springs is generally small, the municipal water supply at Stroudsburg, Monroe County, obtains a million gallons daily from one spring.

In most of the rural regions shallow dug wells are still commonly used. In general they obtain water from rather poor water-bearing material, but the large diameter of the wells provides a large infiltration area and allows ample storage of water. These wells are more likely to fail during dry seasons and are more subject to contamination than the deeper drilled wells.

^a See Meinzer, O. E., Outline of ground-water hydrology: U. S. Geol. Survey Water-Supply Paper 494, pp. 60-68, 1923.

Most of the industrial and municipal ground-water supplies in this area are obtained from drilled wells, and many drilled wells are also used for domestic supplies. Wells drilled for domestic use are generally 6 inches in diameter. Many of those drilled for industrial or municipal use are 10 to 12 inches in diameter, and a few are as large as 24 inches.

Most of the drilled wells obtain water from the consolidated rock formations and are cased through the overlying unconsolidated material, with the casing driven several feet into the bedrock. In the glaciated region the drift is 100 to 300 feet deep in some places, so that considerable casing is necessary to prevent caving. The bedrock, on the contrary, whether it is shale, sandstone, conglomerate, or limestone, is generally self-supporting below the weathered zone, and casing in it is therefore generally unnecessary. Therefore, the water may enter the well along the entire length of the uncased portion of the hole wherever the rock is water-bearing. Drilled wells that end in unconsolidated material are generally cased to the bottom and receive water only through the open end of the casing. In exceptional places where it may be necessary to case off undesirable water, such as that occurring in coal, or where a bed of very soft shale or sandstone is encountered, the casing is carried down through the bedrock, until more favorable conditions are found. A well of this kind may require a reduction in the diameter of the lower portion of the hole and two casings of different diameter, one inside the other.

The intake area and consequently the efficiency of a well drilled in unconsolidated material may be greatly increased in several ways. The simplest way to increase the intake area is by perforating those portions of the casing that are opposite the water-bearing beds. In drilling such a well samples of material should be taken every few feet, and the depth and thickness of water-bearing beds should be carefully recorded, in order to know where to perforate the casing and in order to select the proper size for the perforations. A more efficient method of increasing the intake area of a well is by the use of well screens. Well screens are manufactured in many different sizes and types, and the grain size of the water-bearing material determines the size of openings to be used in the screen. Some well screens are surrounded by a layer of carefully screened gravel of proper size. This is commonly used in fine material, for by increasing the diameter and intake area of the well screen with gravel, the velocity of the incoming water is reduced sufficiently to prevent the finer material from entering the well.

As pointed out on page 30, it is surprising that in an area containing an abundance of water-bearing sand and gravel in many places, only a few attempts at efficient recovery have been made. There are very few perforated casings in use, and not more than half a dozen wells were found in which screens had been installed. The three wells of the

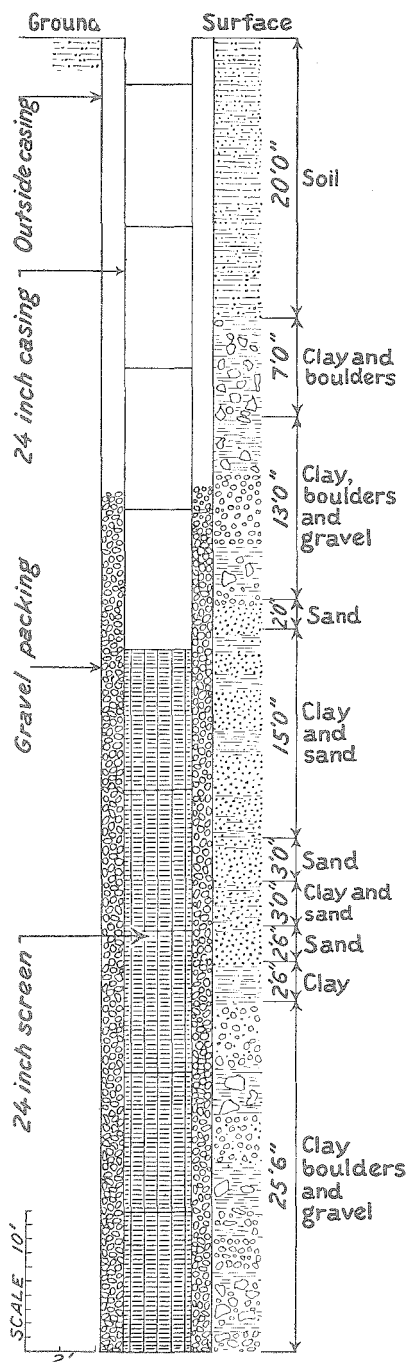


Figure 5.—Sectional view of gravel-walled screened well of the Stanton Operating Co., near Pittston (well 294). From data furnished by the company.

Stanton Operating Co., near Pittston, are good examples of modern well construction and are by far the strongest wells noted in northeastern Pennsylvania (wells 294, p. 148 and fig. 11). These wells have an inside diameter of 24 inches and are about 96 feet deep, ending in outwash gravel and sand. In the lower 50 feet of each of these wells the casing is replaced by a screen surrounded by carefully selected gravel, the details of which are shown in figure 5. Each well was tested at 1,280 gallons a minute, with a draw-down of only 9 to 10 feet after 8 hours' continuous pumping. (See also wells 295, 353, pp. 148, 153 and fig. 11.) Doubtless many more wells of this type could be drilled in northeastern Pennsylvania.

When water is withdrawn from a well there is a difference in head between the water inside the well and the water in the material outside the well. The water table in the vicinity of a well that is discharging water has a depression somewhat in the form of an inverted cone, the apex of which is at the well. In areas of artesian conditions the cone of depression in the piezometric surface (the imaginary surface indicating the height to which the unimpeded water would rise), exists only as an imaginary cone with the apex of the cone at the point of discharge of the well. In any given well the greater the pumping rate the greater will be the draw-down and the greater the diameter of the cone of depression. If the well is pumped heavily the water levels in wells several hundred feet or even a few miles away may be lowered somewhat.

The specific capacity of a well is its rate of yield per unit of draw-down, and is usually stated in gallons a minute per foot of draw-down. For example, well 294 was described as yielding 1,280 gallons a minute with a draw-down of about 10 feet. Its specific capacity is therefore said to be 128 gallons a minute per foot of draw-down. Wells in some of the consolidated rocks may yield less than 1 gallon a minute for each foot of draw-down.

When a well is pumped the water level drops rapidly at first and then more slowly but may continue to decline for several hours or days. Therefore, in testing the specific capacity of a well, it is important to continue pumping until the water level remains approximately stationary. When the pump is stopped, the recovery is likewise rapid at first but tapers off slowly and may continue long after pumping has ceased. Figure 6 shows a recovery curve obtained on a well that was not being pumped, after the pumps were stopped on two nearby wells. (See pp. 95, 96.) The water level was still rising slowly 76 minutes after the pumps were stopped, and had measurements been continued, they probably would show that the rise continued considerably longer. Figure 6 also shows that well 975 is within the cones of depression of the two pumped wells, and that these cones undoubtedly intersect and interfere with each other. (See wells 975, 976, 977, pp. 95, 103, and fig. 8.)

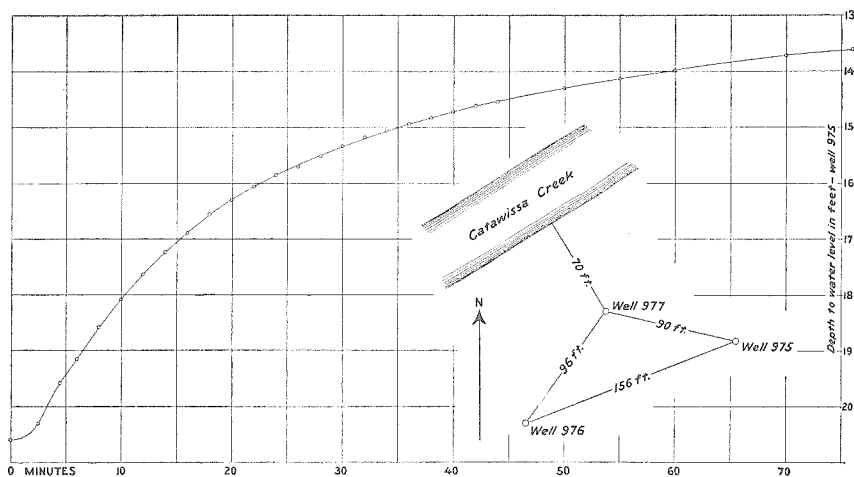


Figure 6.—Recovery curve of well 975, near Catawissa, with a sketch showing the location of the Catawissa Water Co.'s drilled wells.

It is obvious that as the cost of pumping water increases with the draw-down, a material saving can be effected by increasing the specific capacity of a well by means of the modern methods of well construction suggested in the foregoing paragraphs.

QUALITY OF WATER

During the course of the field work 106 samples of water were collected from wells and springs and were analyzed in the laboratory of the quality of water division of the United States Geological Survey, by Margaret D. Foster, L. A. Shinn, and K. T. Williams. The analyses for each county are tabulated in the county descriptions.

The mineral constituents of the natural waters here considered include all that are found in normal waters in quantities sufficient to have any practical effect on the value of the waters for ordinary uses. The following statements regarding mineral constituents have been prepared by W. D. Collins, chemist in charge of the quality of water division.

Silica (SiO_2) is dissolved from practically all rocks. A few natural waters contain as little as 3 parts per million of silica, and some contain more than 50 parts, but most of them contain from 10 to 30 parts. Silica has little effect on the usefulness of a water except as it contributes to the formation of boiler scale.

Iron (Fe) is dissolved from many rock materials and may be dissolved from water pipes in quantities so large as to be objectionable. On exposure to the air, water that contains more than 1 part per million of iron soon becomes turbid with the insoluble iron compound produced by oxidation; surface waters therefore rarely contain as much as 1 part per million of dissolved iron. Many ground waters contain 2 or 3 parts per million, and some even 10 parts or more. Excessive iron in water

causes stains on white porcelain or enameled ware and fixtures and on clothing or other fabrics washed in the water.

Calcium (Ca) is dissolved from practically all rocks but particularly from limestone, dolomite, and gypsum. Calcium and magnesium make water hard and are the active agents in forming boiler scale. Many waters from limestone contain from 30 to 70 parts per million of calcium; and waters that leach deposits of gypsum may contain more than 100 parts.

Magnesium (Mg) is dissolved from many rocks but particularly from dolomite. Its effects are largely similar to those of calcium, but waters that contain much magnesium and chloride are likely to be corrosive, especially in steam boilers. The magnesium in soft waters may amount to only 1 or 2 parts per million, but the ground water in some areas may contain 20 to 50 parts per million of magnesium.

Sodium and potassium (Na + K) are dissolved from practically all rocks, but they make up only a small part of the dissolved mineral matter in most waters in humid regions. The waters of many deep wells are strong solutions of common salt (sodium chloride) and contain smaller quantities of other soluble salts. Sodium and potassium are generally not separated in analyses. Moderate quantities of these constituents have little effect, but waters that carry more than 50 parts per million of the two may require careful operation of steam boilers to prevent foaming. Waters that contain large quantities of sodium salts injure crops, and some waters contain so much sodium that they are unfit for nearly all uses.

Carbonate and bicarbonate (CO_3 and HCO_3) occur in waters largely through the action of carbon dioxide, which enables the water to dissolve carbonates of calcium and magnesium. Carbonate is not present in appreciable quantities in many natural waters. The bicarbonate in waters that come from insoluble rocks may amount to less than 10 parts per million; many waters from limestone contain from 200 to 400 parts per million; and certain waters that contain sodium bicarbonate may carry 1,000 or more parts per million of bicarbonate. The bicarbonate as such has comparatively little effect, although a large quantity may make water unsatisfactory for drinking and other domestic uses.

Sulphate (SO_4) is dissolved in large quantities from gypsum and from deposits of sodium sulphate. It is also formed by the oxidation of sulphides of iron and is therefore present in considerable quantities in waters from mines and from many beds of shale. Some alkali waters contain more than 1,000 parts per million of sulphate. Sulphate in waters that contain much calcium and magnesium causes the formation of hard scale in steam boilers and may increase the cost of softening the water.

Chloride (Cl) is dissolved in small quantities from rock materials in

most parts of the country. The chloride in waters has little effect on their use unless it is present in excessive quantities, as in brines.

Nitrate (NO_3) in water is considered a final oxidation product of nitrogenous organic material. The quantities usually present have no effect on the value of water for ordinary use.

Hardness is usually expressed as the quantity of calcium carbonate (CaCO_3) equivalent to the calcium and magnesium present. Water that has less than 50 parts per million of "hardness," as thus determined, is usually rated as soft, and its treatment for removal of hardness is rarely justified. Hardness between 50 and 150 parts per million does not seriously interfere with the use of water for most purposes, but it does slightly increase the consumption of soap, and its removal by softening processes will be profitable for laundries or other industries that use large quantities of soap. Hardness beyond 150 parts per million is noticed by anyone, and in many places where natural waters have hardness of 200 to 300 parts per million cisterns are used for storing rain water for use in laundry work.

In northeastern Pennsylvania the water obtained from glacial drift contains very small amounts of dissolved mineral constituents, as a rule considerably less than waters from the consolidated rock formations. The amounts of dissolved mineral matters in waters from the different rock formations vary widely, even for a single formation, and are therefore not characteristic for any one member, but certain groups of formation generally show similarities. Waters from formations composed of light-colored conglomerate or sandstone and red or green shale generally contain less dissolved mineral matter than waters from formations composed of dark-colored shales, slates, or sandstones. The first group includes the Pottsville, Pocono, Mauch Chunk, and Catskill formations and those parts of the Cayuga group and Clinton formation which are free from calcareous deposits. The second group includes the Chemung, Portage, Hamilton, and Marcellus formations. However, in both groups there are local exceptions. The waters containing the largest amounts of dissolved mineral matter come from limestone. Limestone underlies only a very small part of the area here described, and only six samples of water from limestone were obtained, so that no attempt will be made to differentiate the different limestone formations, except to point out that waters from thin-bedded limestone of Cayuga age generally contain much more dissolved mineral matter than waters from the Tonoloway, Bossardville, Helderberg, or Onondaga limestone.

In many parts of Pennsylvania iron is the most objectionable mineral constituent in ground water. In northeastern Pennsylvania, however, the amount of iron in solution in ground water is generally small or negligible. Water pumped or drained from the numerous coal mines generally contains an abundance of iron derived from the oxidation of

pyrite in the coal, but, as will be pointed out in the county descriptions, the post-Pottsville formations (coal measures) are not sources of potable ground water, owing to mining conditions, except in a few localities. In the other water-bearing formations the water generally contains considerably less than 1 part per million of iron—in some only 0.01 part per million. The few waters that contain more than 1 part per million are widely scattered and are not characteristic of one rock type or one region. Waters containing more than 1 part per million of iron (other than acid mine waters) generally become turbid when exposed to air, the iron being oxidized, except for a very small amount that remains in solution. It is evident, therefore, that most of the iron can be precipitated out of solution by proper aeration by means of nozzles or devices of the umbrella type. The precipitated iron can then be removed by filtration, either with or without coagulation.¹⁰

In northeastern Pennsylvania no ground waters are known to be treated for the removal of iron, and indeed, this would be desirable only in a very few places. The drilled well of the Bloomsburg Ice & Cold Storage Co., in Bloomsburg, Columbia County (well 970, p. 102 and fig. 8), yields relatively clear, hard water, but on exposure to the air it becomes turbid. It was reported that when an attempt was made to use this water for making ice, a red precipitate formed at the center of each ice cake, thus ruining the ice. As shown by the analysis on page 97, this water formed a precipitate containing 6.6 parts per million of iron. With proper aeration most of this iron could be removed, so that the ice cakes would not be discolored.

In a few places in the area deep drilled wells encounter water which is high in sodium chloride (NaCl, or common salt). Most of these occurrences are in regions underlain by the marine Chemung formation, but a few occurrences of slightly salty water were noted in some of the other formations. The occurrence of salt water is only local, however, and the few localities where it is present are noted in the county descriptions. Many of the rocks in this area were deposited in sea water, some of which became entrapped in the sediments (connate water), and this is probably the source of most of the deep-seated salty or brackish water.

Several industries in northeastern Pennsylvania require water for cooling. Either surface water or ground water may be used for this purpose, but the ground water is much more satisfactory than surface water because of its relatively uniform temperature throughout the year. The temperature of surface water approximates the mean monthly temperature of the air,¹¹ and consequently surface water is cold in winter but warm in summer. On the contrary, the temperature of ground water

¹⁰ For further details see McNamee, R. L., The removal of iron from hard ground waters: *Am. Water Works Assoc. Jour.*, vol. 21, no. 6, pp. 758-767, 1929.

¹¹ Collins, W. D., Temperature of water available for industrial use in the United States: *U. S. Geol. Survey Water-Supply Paper* 520, pp. 97-101, 1925.

approximates the mean annual temperature (see p. 5), which is generally less than 50° F. Water in deep wells more closely maintains the mean annual temperature than water in shallow wells, so that water from deep drilled wells is ideally suited for cooling. The chemical or sanitary character of water used for cooling is unimportant, and in several places in northeastern Pennsylvania water that would be regarded as unfit for boiler use is used satisfactorily for cooling.

Hydrogen sulphide (H_2S), a gas which has an odor similar to that produced by the decomposition of eggs, is believed to originate generally from the reduction of sulphates. In northeastern Pennsylvania small quantities of hydrogen sulphide are present in some of the waters derived from dark-colored shales or sandstones. Aside from imparting a slight odor and taste to the water, it is entirely harmless in the quantities present.

The analyses of water given at the end of this report show only the amounts of dissolved mineral matter in the water and do not indicate the sanitary quality of the water. As already mentioned, properly constructed drilled wells are less subject to contamination than dug wells and springs. During the drought of 1930-31 the danger of contamination of the dug wells and springs was increased, and drought-relief work was begun in Pennsylvania on March 15, 1930, and carried on until August 31, 1931, in cooperation between the Pennsylvania Department of Health and the United States Public Health Service. During this time 17,665 water supplies in 23 counties, including 4 counties in the area described in this report, were investigated as to the sanitary quality of the water. More than 90 percent of the drilled wells that were examined in these 4 counties were found to be free from contamination, whereas the proportion of safe supplies from dug wells examined was less than 50 percent, and that from springs examined was less than 40 percent. For this information, which is shown in more detail in the following table, the writer is indebted to Mr. Bernard S. Bush, assistant engineer of the Pennsylvania Department of Health, who was in charge of the field operations.

Proportions of safe water supplies from wells, springs, and cisterns in four counties in northeastern Pennsylvania, 1930-31

(Information furnished by Bernard S. Bush, Pennsylvania Department of Health)

County	Number of supplies examined	Type of supplies, in percent of total number examined					Safe supplies, in percent of total number of each type				
		Wells			Springs	Cisterns	Wells			Springs	Cisterns
		Drilled	Dug	Dug and drilled			Drilled	Dug	Dug and drilled		
Columbia	1,311	20	72	1	7	1.8	97	40	100	35	96
Dauphin	958	19	0.2	3	76	1	90	None	70	25	90
Northumberland	1,462	21	70	1	7		96	59	70	50	
Schuylkill	611	23	65	1	11		85	42	None	30	

WATER-BEARING FORMATIONS

QUATERNARY SYSTEM

RECENT ALLUVIUM

Recent deposits of silt, sand, and gravel are found along all the streams in this area, but they are thin and unimportant as sources of ground water. A part of this material is derived from the disintegration of the bedrock by rain, frost, and stream erosion, and a part is derived from the reworking of glacial drift, which fills the valleys north of the drift borders.

Another type of material being deposited in the stream beds of northeastern Pennsylvania is very fine coal, or culm, which is discharged into the streams in enormous quantities from the numerous coal washeries.¹² Wherever it is turned into a small stream that does not carry enough water to transport the culm, the stream bed soon becomes filled, and in some streams no channel is left, the water running at will over the adjoining flat lands. The Lackawanna and Schuylkill Rivers and numerous smaller streams, like Shamokin Creek, deposit large amounts of culm. This transported coal is dredged at numerous places along the Susquehanna River as far south as Holtwood, Lancaster County.

PLEISTOCENE GLACIAL DRIFT¹³

More than half of the area described in this report was covered by ice during some of the glacial stages of the Pleistocene epoch. Glacial deposits of at least three ages—from oldest to youngest the Jerseyan, Illinoian, and Wisconsin—are preserved in northeastern Pennsylvania. The drift borders or southern limits of these deposits are shown on plate 1.

As the ice advanced, the soil and decomposed rock were scraped off and shoved along. Masses of bedrock were plucked out by the ice and, held firmly, formed tools with which the glacier scoured the bedrock. Many grooves and striae produced in this manner are still preserved on smooth rock surfaces and show that the general direction of ice movement was about S. 30° W. Except for a few high peaks, which were probably "islands in the sea of ice," the glacier covered the entire northern part of the area, traversing mountains as well as valleys. When the ice sheets reached their southern limits and warmer climatic conditions forced them to retreat by melting back slowly, they left terminal moraines, consisting of a heterogeneous accumulation of unstratified clay, sand, gravel, and boulders.

¹² A coal washery is a plant erected for the purpose of working over the old waste or culm piles, to recover coal which in earlier times under cruder methods of handling passed out as waste.

¹³ See Leverett, Frank, *Glacial deposits outside the terminal moraine in Pennsylvania*: Pennsylvania Geol. Survey, 4th ser., Bull. G-7, 123 pp. 38 figs., 2 pls. (incl. map), 1934.

The oldest glacial drift in the area is called the "Jerseyan drift." This is no longer marked by a well-defined terminal moraine, and the Jerseyan drift border shown on plate 1 simply indicates the southernmost limit where glacial deposits have been found and includes some areas of questionable glaciation. No extensive deposits of Jerseyan drift were observed, and it is unimportant as a source of ground water.

The Illinoian drift border is generally not far south of the Wisconsin drift border, except along Lehigh River and the North and West Branches of the Susquehanna River, where long, narrow lobes of ice extended farther south. In most places the Illinoian drift border is not marked by a well-defined terminal moraine, the absence of which is due to subsequent erosion. The noteworthy deposits of Illinoian drift are described in the sections on Carbon, Columbia, Montour, and Northumberland Counties. Illinoian drift is unimportant as a source of ground water in northeastern Pennsylvania except in Carbon County and to some extent in Columbia, Montour, and Northumberland Counties. It yields large supplies of potable water in the valley of Aquashicola Creek, in Carbon County. It probably supplies a few dug wells in Columbia, Montour, and Northumberland Counties, but no attempts have been made to recover large quantities of water from it.

The Wisconsin drift, resulting from the most recent glaciation, covers the north half of the area and is marked by a well-defined terminal moraine crossing the area as a series of low hills, hummocks, knobs, and ridges interspersed with depressions, called "kettles," many of which are filled with water. These depressions are due to slumping caused when a block of ice contained in the drift melted. This terminal moraine enters the area in southern Monroe County, traverses it in an irregular, sinuous line, and leaves it in northern Columbia County.¹⁴ Its course through the area is set forth in more detail in the county descriptions. As the Wisconsin ice cap retreated it left drift of two different types in till and outwash.

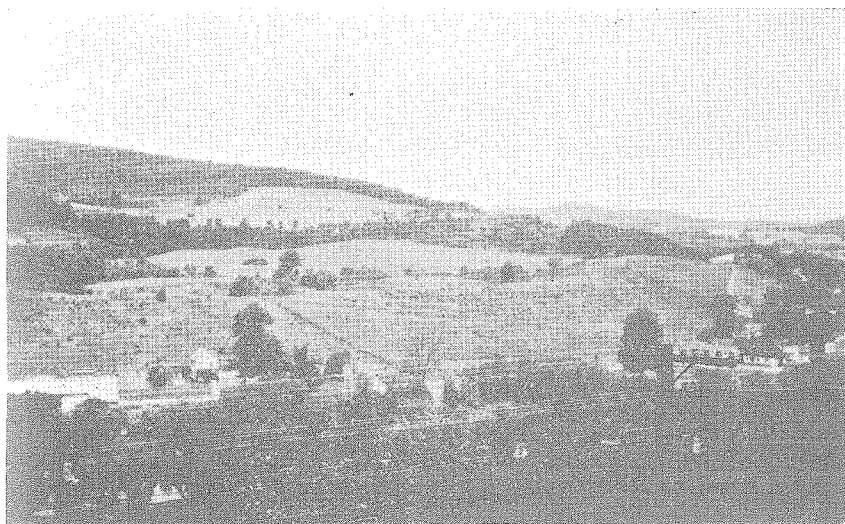
Till is an unstratified deposit of material that has been dropped directly by the melting ice and has not been sorted by running water. It usually consists of fine, impure clay containing stones of all sizes and shapes, without sorting. Many of the pebbles show one or more facets, or flat sides, which may be grooved or striated. The facets indicate that the pebble was once frozen in the ice and ground flat against the bedrock. Deposits of stratified drift, usually clay, sand, and gravel, which have been sorted by running water are in many places associated with the till. Many of the transported boulders, or "erratics," dropped by the ice consist of rock whose source is known to be hundreds of miles north of the area.

¹⁴ Lewis, H. C., Report on the terminal moraine in Pennsylvania and western New York: Pennsylvania Geol. Survey, 2d ser., Rept. Z, pp. 1-125, 1884.

Plate 6



A. Terraces of glacial outwash along Tunkhannock Creek $\frac{1}{8}$ mile east of Nicholson, Wyoming County (looking northeast from a point on top of the highest terrace)



B. Morainic topography one mile east of Oakland, Susquehanna County

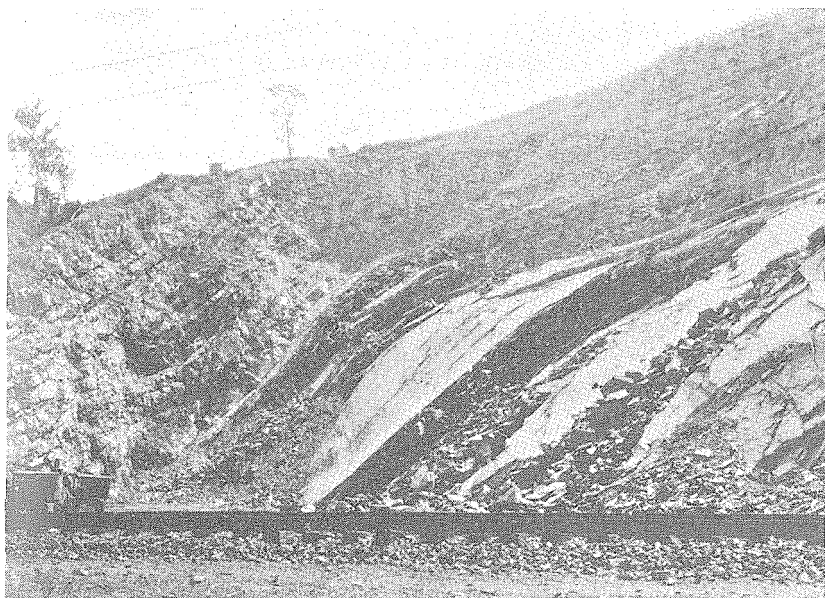
Glacial drift consisting of till and stratified material covers the area north of the Wisconsin drift border and ranges in thickness from a few feet to several hundred feet, except in places where subsequent erosion has removed it. Many valleys were filled up and the streams forced to find new channels over or around the buried valleys. Many of the streams were dammed up by thick deposits of drift, forming lakes, and other streams were diverted from their preglacial courses by heaps of drift, which caused them to flow over cliffs, forming waterfalls. Lakes and waterfalls of glacial origin are numerous north of the Wisconsin drift border. Much of the drift-covered terrane presents a hummocky topography, with odd-shaped hills or mounds of drift and undrained depressions (pl. 6-B). The water-bearing properties of glacial till are described on pages 28-30.

The swollen streams that issued from the melting of the ice sheet transported an immense quantity of material. Whenever the quantity of material exceeded the transporting power of the streams, the material was dropped, and when the streams carried lighter burdens they cut through the outwash material, leaving terraces (pls. 2-B and 6-A). Deposits of glacial outwash fill the larger valleys north of the Wisconsin drift border (pl. 3-A) and extend as "outwash trains" beyond the border. The outwash material consists of clay, sand, "quicksand," and gravel (pl. 7-B).

Many of the valleys were excavated by preglacial erosion much deeper than they are at present, and these deep channels were later filled with clay, sand, and gravel, so that the present streams flow over deeply buried valleys in many places. Locally the depth of the sediments filling these old channels is more than 300 feet, but generally the depth ranges from 50 to 150 feet. The Wyoming Valley of the North Branch of the Susquehanna River is one of the most notable examples of such filling, for from Pittston to Nanticoke it is underlain by a deposit of sand, gravel, and clay which attains a thickness of 309 feet at one locality and is more than 100 feet thick under an area of nearly 20 square miles.¹⁵ A cross section of the Wyoming Valley is shown in figure 4.

The occurrence of water in the glacial outwash is described on page 30. The thickness and character of the glacial drift varies in the different counties, and the deposits are therefore described separately for each county.

¹⁵ Darton, N. H., Sand available for filling mine workings in the Northern Anthracite Basin of Pennsylvania; U. S. Bur. Mines Bull. 45, p. 6, 1913.



A. North limb of anticline in the Montebello sandstone in the Hamilton formation, Susquehanna Stone Co. quarry, $2\frac{1}{2}$ miles south of Dalmatia, Northumberland County



B. Glacial outwash exposed in highway cut south of Bushkill, Monroe County

CARBONIFEROUS SYSTEM**PENNSYLVANIAN SERIES****POST-POTTSVILLE FORMATIONS**

General features.—The post-Pottsville formations include the most important economic deposit of northeastern Pennsylvania—anthracite. They are preserved from erosion in four synclinal basins—(1) the Northern or Wyoming-Lackawanna field, which is the northeasternmost and is about 55 miles long and 6 miles wide at the center; (2) the Eastern Middle field, lying about 10 miles southwest of the northern field and comprising a number of small coal basins; (3) the Western Middle or Mahanoy and Shamokin field, which joins the Eastern Middle field on the southwest; and (4) the Southern field, which is the largest of the five, being about 70 miles long and having a maximum width of 8 miles near Pottsville.

The Pennsylvania Second Geological Survey recognized but two divisions in the Pennsylvanian rocks of this region—the Pottsville and post-Pottsville formations. David White¹⁶ has tentatively divided the post-Pottsville rocks of this region into the Allegheny and Conemaugh formations, placing the Checker coal bed of the Northern field and the Holmes coal bed of the Western Middle and Southern fields as the approximate upper limit of the Allegheny formation. The next higher formation of the Pennsylvanian series, the Monongahela, has not been definitely recognized in this area and may have been completely removed by erosion.

Inasmuch as the Allegheny and Conemaugh formations are unimportant as sources of potable ground water in most parts of northeastern Pennsylvania, no attempt was made to separate them in the field, and they are here described together as the post-Pottsville formations.

The post-Pottsville formations lie conformably on the Pottsville. Their greatest thickness is found in the deep basins of the Southern anthracite field, where the total thickness is more than 2,500 feet. The thickness in the Western Middle anthracite field is about 1,500 feet; in the Northern field, about 1,800 feet. All of the Conemaugh formation has been swept away by erosion in the Eastern Middle field so that the deepest basin (Hazleton basin) contains only about 700 feet of the Allegheny formation. Neither of these formations is found in the Mehoopany coal basin, in Wyoming County, where the coals are obtained entirely from the Pottsville formation.

The post-Pottsville formations consist of beds of sandstone, some coarse and hard grading down to fine, soft and shaly; shale; fireclay; black carbonaceous slate or shale; and beds of coal ranging from seams a few inches thick to the great Mammoth bed, with a thickness over

¹⁶ Personal communication.

large areas of 50 to 60 feet. The prevailing color of the sandstones and shales is brown or gray. Beds of both fine and coarse conglomerate, which closely resemble the underlying Pottsville conglomerates, occur between the coal beds. Beds of fireclay usually but not everywhere underlie the coal beds, and in many places fireclay occurs in the intervals between seams of coal. The occurrence of limestone beds interstratified with the shales, sandstones, and coal beds, although characteristic of all the bituminous coal fields of the State, is rare in the anthracite region. The only localities where clearly defined and persistent limestone beds have been found are in the Wyoming Valley where some four thin beds of limestone, 1 to 3 feet thick are exposed at different points in the valley, but chiefly in the vicinity of Wilkes-Barre.¹⁷ The post-Pottsville formations are everywhere softer and less resistant to erosion than the underlying Pottsville formation. For this reason and because they constitute the cores of the synclinal basins, the post-Pottsville beds form relatively flat valleys surrounded by protecting ridges of the Pottsville rocks.

Ground-water conditions.—The post-Pottsville formations are unimportant as sources of potable ground water in all the coal basins except the Southern field of Schuylkill County and perhaps the Wyoming Valley in Luzerne County. In the central part of Schuylkill County small to large supplies of good water are obtained from post-Pottsville sandstones and conglomerates in places sufficiently removed from mining operations. (See p. 239.) In other parts of the Southern field, as well as in most of the other fields, the water is generally unfit for ordinary use, owing chiefly to the oxidation of the pyrite contained in the coal, which results in a highly acidic water. Large quantities of water are pumped from the mines and utilized for washing coal, which results in a material loss in head, so that wells which might otherwise be usable are generally dried up. These conditions vary somewhat among the different fields and are discussed in greater detail in the county descriptions.

POTTSVILLE FORMATION

General features.—The Pottsville formation is a coarse, mainly quartzose mass, made up chiefly of gray conglomerate, white, gray, and brownish sandstone, in some places red and green sandstone, a few thin beds of carbonaceous slate, and in most places a few thin seams of coal. The Pottsville coal beds are large and valuable in the west end of both the Southern and the Western Middle fields but decrease in size and number toward the east and are seldom worked in the other fields. The greater part of the formation consists of hard, coarse conglomerate,

¹⁷ Ashburner, C. A., Report on the Wyoming Valley Carboniferous limestone beds: Pennsylvania Geol. Survey Ann. Rept. for 1885, pp. 437-450, 1886; Wyoming Hist. & Geol. Soc. Proc., vol. 2, pp. 254-264, 1886.

making a solid, resistant base upon which the softer post-Pottsville formations rest conformably. Thus the Pottsville formation has been an important factor in preserving what little remains of the valuable overlying coal beds, for its outcrop forms a protecting and enclosing ridge around each of the coal basins. It overlies disconformably the Mauch Chunk formation or the Pocono sandstone.

The outstanding feature of the Pottsville formation in this region is its comparatively great thickness in the Southern field and its rapid thinning toward its northernmost outcrop, in the Northern field near Forest City, accompanied by a decrease in the coarseness of the materials and also by a decrease in the number and thickness of workable coal beds. Thus the 1,100 to 1,475 feet of massive, coarse conglomerate in the Southern field diminishes to scarcely 200 feet of coarse sandstone with only a scattering of pea-sized pebbles at Forest City. At the west end of the Southern field there are six Lykens Valley coal beds and the White's coal bed in the Pottsville formation.¹⁸ The Western Middle field contains only three Lykens Valley coal beds, and the Eastern Middle and Northern fields contain only the Alpha or A coal bed.

Grabau¹⁹ explains this gradual diminution toward the north on the ground that the Pottsville formation is a terrestrial river deposit that overlaps away from the source of supply, the material being derived from the southeast. Thus the material becomes thinner and finer-grained toward the north. The Pottsville formation of the Southern field has been divided into lower, middle, and upper Pottsville, on the basis of the fossil plants. Only the upper Pottsville plants are found in the Northern field, so it appears that the diminution in thickness is due to the fact that deposition in the Southern field began much earlier than it did to the northeast.

The boundary between the Pottsville and the post-Pottsville formations was arbitrarily fixed by Rogers²⁰ "at the bottom of the first or lowest considerable coal seam," but according to White²¹ it appears that the conventional upper limit of the Pottsville is higher than the paleontologic upper limit. The placing of the lower limit of the Pottsville is difficult, owing to the transitional character in most places of the typical Mauch Chunk shale into the overlying conglomerate. Both the First and Second State Geological Surveys fixed arbitrary boundaries between the two formations, and White²² has "adopted the topmost bed of normal red shale in each section as the lower boundary of the Pottsville formation.

¹⁸ Griffith, William, Approximate columnar sections showing the correlation of anthracite coal beds of Pennsylvania: *Colliery Eng.*, vol. 34, no. 3, suppl., 1913.

¹⁹ Grabau, A. W., Types of sedimentary overlap: *Geol. Soc. America Bull.*, vol. 17, pp. 629-634, 1906.

²⁰ Rogers, H. D., *The geology of Pennsylvania*, vol. 2, pt. 1, p. 17, 1858.

²¹ White, David, The stratigraphic succession of the fossil floras of the Pottsville formation in the southern anthracite coal field, Pennsylvania: *U. S. Geol. Survey 20th Ann. Rept.*, pt. 2, p. 830, 1899.

²² *Idem*, p. 832.

Ground-water conditions.—The Pottsville formation is an important water-bearing formation in Luzerne and Schuylkill Counties, but in most of the other counties it crops out only on high, rugged ridges. In Luzerne and Schuylkill Counties it yields moderate to large supplies of good water, and as the structural conditions are generally favorable, many of the wells flow. (See pp. 139, 240.)

MISSISSIPPIAN SERIES

MAUCH CHUNK SHALE

General features.—The outcrops of the Mauch Chunk shale probably surround nearly all of the anthracite fields, occurring beneath the Pottsville formation. With respect to its rapid diminution in thickness toward the northeast it is similar to the overlying Pottsville and post-Pottsville formations, for the Mauch Chunk is 2,000 or 3,000 feet thick on the south side of the Southern field, is only 200 or 300 feet thick on the north side of the Northern field, is known doubtfully by a few feet of greenish shale northwest of Pittston, while farther northwestward the Mauch Chunk is absent and the Pottsville rests directly on the Pocono in evident disconformity. The Mauch Chunk is characteristically a valley-forming rock, because it is soft and lies between two exceptionally hard rock formations, the Pottsville and the Pocono.

The outstanding characteristic of the Mauch Chunk is its prevailing red color, and it is commonly spoken of as the "red shale" or the "red shell." It is not all red, however, nor is it all shale, but consists of red, green, yellow, and brown shale with some sandstones. Toward the south red shale and sandstone predominate, but toward the north the red beds thin out to a knife edge and finally disappear altogether, leaving chiefly green beds, which in turn disappear as stated above.

Opinions have differed somewhat as to the origin of the Mauch Chunk shale. Rogers²³ ascribed to it an origin in a shallow sea, and Lesley²⁴ believed that the "red shale" was deposited on a broad shore-bordered lowland near sea level, occupied by marshes, pools, and lagoons. Grabau²⁵ and subsequently Barrell²⁶ reached more definite conclusions. Barrell concluded that in the anthracite region, more surely in the southeastern and eastern portions, the whole formation, from top to bottom, was a subaerial delta deposit laid down under a semiarid climate. Footprints of vertebrates, plant impressions, mud cracks, water marks and possibly rain prints have been found, all of which point to the subaerial origin of the Mauch Chunk.

Ground-water conditions.—The Mauch Chunk shale is one of the most productive water-bearing formations in northeastern Pennsylvania.

²³ Rogers, H. D., *The geology of Pennsylvania*, vol. 2, pt. 2, p. 794, 1858.

²⁴ Lesley, J. P., *Pennsylvania Geol. Survey, Final Rept.*, vol. 3, pt. 1, p. 1807, 1895.

²⁵ Grabau, A. W., *op. cit.*, pp. 632-634.

²⁶ Barrell, Joseph, *Origin and significance of the Mauch Chunk shale: Geol. Soc. America Bull.*, vol. 18, pp. 449-476, 1907.

In Carbon, northern Dauphin, Luzerne, Northumberland, and Schuylkill Counties and to a lesser degree in Columbia County it adequately supplies numerous shallow domestic wells with water of excellent quality and yields moderate to large supplies to deeper municipal and industrial wells. Many of these deeper wells flow, particularly in the outcrop areas of the Mauch Chunk closest to the synclinal coal basins. The Mauch Chunk also crops out in Lackawanna, Susquehanna, Wayne, and Wyoming Counties, where it is of practically no importance as a source of ground water.

POCONO SANDSTONE

General features.—The Pocono sandstone disconformably underlies the Mauch Chunk shale or the Pottsville formation. It consists principally of hard massive gray sandstone and conglomerate and is the most effective mountain maker of the area. High ridges of the Pocono completely surround all of the coal fields, and form the high North Mountain of western Luzerne and Wyoming Counties. The Pocono was formerly thought to cover nearly the entire Pocono plateau in parts of Carbon, Lackawanna, Luzerne, Monroe, and Pike Counties, an error that still appears on the latest geologic map of Pennsylvania.²⁷

The definition, age, and distribution of the Pocono at its type locality have been widely discussed in recent years, and the very existence of Mississippian Pocono on the Pocono Plateau has been questioned.²⁸ In recent studies of the continental Devonian deposits of northeastern Pennsylvania, Willard²⁹ has apparently solved this disputed question by demonstrating that although most of the strata of the Pocono Plateau are of Devonian age, there is Pocono of probable Mississippian age in the Moosic Mountains forming the western border of the plateau.

Willard³⁰ recognizes in southern and central Pennsylvania a three-fold subdivision of the Pocono as follows: a lower conglomeratic member; a middle platy division, the Peters Mountain sandstone; and a massive conglomeratic upper member, the Burgoon sandstone. In the northeast the Griswold Gap conglomerate is locally present at the base. In the southwestern part of the area the basal member is the massive, conglomeratic "Berea" sandstone. In addition to gray or buff sandstone and conglomerate the Pocono includes some thin beds of green sandstone and red or buff shale. The Pocono ranges in thickness from about 600 feet in the northern part of the area to about 1,600 feet in

²⁷ Geologic map of Pennsylvania: Pennsylvania Topographic and Geologic Survey, 1931.

²⁸ Chadwick, G. H., Great Catskill Delta: Pan-American Geologist, vol. 60, pp. 91-107, 189-204, 275-286, 348-360, 1933. (Correction sheet distributed by author).

_____, What is "Pocono": Am. Jour. Sci., 5th ser., vol. 29, pp. 133-143, 1935.

White, David, The age of the Pocono: Am. Jour. Sci., 5th ser., vol. 27, pp. 265-272, 1934.

Ashley, G. H., and Willard, Bradford, The use of the term Pocono: Science, ser. 5, vol. 81, pp. 615-617, 1935.

²⁹ Willard, Bradford, Continental Upper Devonian of northeastern Pennsylvania: Geol. Soc. America Bull., vol. 47, pp. 565-608, 1936.

³⁰ Willard, Bradford, Idem, p. 573.

the southern part, accompanied by a decrease in coarseness toward the north similar to the overlying Carboniferous formations.

The Pocono sandstone in this area was formerly believed to be entirely nonmarine, on the basis of a nonmarine type of overlap, a varied fresh water flora, and the general absence of marine fossils. Marine fossils have been found in the Pocono in other regions. What is thought to be the Riddlesburg marine shale (middle Pocono) has been observed at Peters Mountain, Dauphin County, by Willard.³¹ Coal beds occur in the Pocono but they are generally thin and local. A 4-foot bed of coal³² was recently mined from the Pocono on Peters Mountain, but the workings have been abandoned (1936).

Ground-water conditions.—The Pocono sandstone yields moderately large supplies of water to deep wells, several of them flowing wells, in Lackawanna and Luzerne Counties and supplies a few wells in Carbon, Dauphin, and Northumberland Counties, but is unimportant in the other counties where it is exposed chiefly because of the inaccessibility of its outcrops. The wells in the Pocono generally yield water of very good quality.

DEVONIAN SYSTEM³³

UPPER DEVONIAN SERIES

CATSKILL CONTINENTAL GROUP

General features.—The Catskill continental group underlies disconformably the Pocono sandstone. As originally described in the area by White,³⁴ the nonmarine Catskill was thought to overlies everywhere the marine Chemung with "transition" beds between. Later work³⁵ has shown, however, that the Catskill is really a continental phase of Devonian sedimentation that began in eastern New York and northern New Jersey in Hamilton time and whose base becomes progressively younger when traced westward. Thus, in the eastern part of the area and at many places in the western and southern parts the Catskill continental group rests directly on the marine Portage group with no marine Chemung present, whereas in Susquehanna County and at a few places to the south the Catskill rests on the marine Chemung or slightly younger marine formations. Moreover, the nonmarine Catskill beds, which are of Portage, Chemung, and post-Chemung age, can be traced westward into their marine equivalents. Willard's³⁶ use of the term Catskill to

³¹ Willard, Bradford, personal communication.

³² Stose, G. W., and others, *Southern Pennsylvania and Maryland: Internat. Geol. Cong., XVI, United States Guidebook 10*, p. 17, 1932.

³³ The stratigraphy of the Upper and Middle Devonian series in this report is based on recent studies by Dr. Bradford Willard of the Pennsylvania Topographic and Geologic Survey.

³⁴ White, I. C., *Pennsylvania Geol. Survey*, 2d ser., Repts. G-5, 1881; G-6, 1882; G-7, 1883.

³⁵ For an excellent summary of this later work, see Willard, Bradford, "Catskill" sedimentation in Pennsylvania: *Geol. Soc. America Bull.*, vol. 44, no. 3, pp. 495-498, June, 1930.

³⁶ Willard, Bradford, *op. cit.*, p. 498.

include "all the Devonian red beds of whatever chronological position" is followed in this report.

As remapped by Willard³⁷ (see plate 1) the Catskill covers most of Wayne, Pike, Monroe, and Wyoming Counties, covers large areas of Lackawanna, Luzerne, and Carbon Counties, and is present in all of the remaining counties. Its distribution in Susquehanna County is discussed below. The subdivisions of the Catskill recognized by Willard³⁸ are in descending order, as follows:

The highest formation of the Catskill in this area is the Mount Pleasant red shale, consisting of 345 to 596 feet of red shale and sandstone which locally contains conglomerate. It thins out and disappears to the west and loses its identity south of the Pocono Plateau.

The underlying Elk Mountain sandstone consists of green to grayish-green flaggy cross-bedded sandstone with a few beds of shale. It is 100 to 200 feet thick in the northeastern part of the area, but becomes thicker west of the area in north-central Pennsylvania where Willard believes that it passes over into the marine Oswayo formation.

The underlying Cherry Ridge red beds consist principally of red shale and sandstone which locally contains in its upper part a red quartz conglomerate and in its lower part a stratum composed of fragments of shale, fish bone, fossilized wood, and sand, all cemented with lime. The Cherry Ridge is 275 to 500 feet thick in this area and its upper part at least is continuous westward into the red Cattaraugus formation of Potter and McKean Counties.

The next underlying formation, the Honesdale sandstone, consists principally of hard greenish to gray flaggy sandstone but contains some red beds. It is 100 to 200 feet thick in the northern part of the area but thickens southward to 500 to 600 feet where it forms the eastern escarpment of the Pocono Plateau. It is traceable southwest into Dauphin and Perry Counties as the southern summit or shoulder of the generally double-crested Second Mountain. West of Susquehanna County it merges with post-Chemung marine beds.

The underlying Damascus red shale is 125-160 feet thick in the northwestern part of the area but is at least 400 feet thick in Wayne County, 1,500 feet in Monroe County, and forms a large part of the Catskill in Dauphin County. Southwest of Monroe County and in Susquehanna and Wyoming Counties the Damascus is the basal formation of the wholly nonmarine Catskill, and southwest of Monroe County the Damascus is inseparable from the next older continental formation, the Shohola, which rests on the marine Portage group.

In Pike, Wayne, and Monroe Counties the Damascus is underlain by three nonmarine formations, in order, the Shohola formation, the Dela-

³⁷ Willard, Bradford, *Continental Upper Devonian of northeastern Pennsylvania*: Geol. Soc. America Bull., vol. 47, pp. 565-608, 1936.

³⁸ Willard, Bradford, *idem.*, pp. 574-593.

ware River flags, and locally the Anolomink red shale. The Shohola consists principally of olive-green and gray shale and cross-bedded sandstone with some red beds. It attains a thickness of about 725 feet in Pike County and, westward, merges with the Damascus in Monroe County. The Delaware River flags comprise 1,500 feet of nearly unfossiliferous greenish flaggy sandstone without red beds, which, in southwestern Monroe County become marine and inseparable from the Trimmers Rock (Portage) sandstone. In Pike and Monroe Counties the Delaware River flags are separated locally from the underlying marine Portage by the Anolomink red shale, which is about 100 feet thick. These three formations do not appear west of the Lackawanna syncline as described below.

In Susquehanna County, and small parts of Wayne and Wyoming Counties, the Damascus is underlain by the New Milford formation and in northwestern Wyoming County by the marine Chemung or slightly younger strata. The New Milford, whose maximum thickness is 400 to 500 feet, consists largely of greenish to grayish massive or crossbedded flaggy sandstone with locally a basal red member and a thin marine coquinite or limestone near the top. It contains both marine fossils and abundant land plants in its lower two-thirds, the upper third is largely nonmarine, but as a whole it consists of alternating continental and marine beds of Chemung and post-Chemung age. It is here included with the Catskill mainly because its water-bearing properties are similar to the wholly nonmarine portions of the Catskill but differ from the underlying wholly marine Chemung formation.

The total thickness of the Catskill continental group (including the New Milford) ranges from about 1,800 feet in Susquehanna County to about 6,000 feet in Carbon County.

Ground-water conditions.—The Catskill is an important water-bearer in all the counties covered by this report and is perhaps the most important water bearer in the area. It crops out over a larger area and hence supplies more drilled wells than any of the other formations. It is of special importance in the counties embraced in the Appalachian Plateaus province, as it underlies nearly all of that area. It contains numerous beds of water bearing sandstone, such as the ones shown in Plate 5-A, one or more of which can generally be reached by wells of moderate depth, and the wells as a rule yield moderate to large supplies of good water. Locally, in northwestern Lackawanna County, deep wells may encounter brackish water. As the several formations of the Catskill had not been mapped separately at the time the field investigation was made, the wells are not classified according to separate formations but are all listed as ending in the Catskill.

CHEMUNG FORMATION

General features.—The Chemung formation as used in this report includes only the wholly marine beds of Chemung age, those beds of Chemung age which are partly or wholly continental being included in the overlying Catskill continental group. Willard³⁹ has shown that in northeastern Pennsylvania the marine Chemung is present only in Susquehanna and Wyoming Counties, except for a few feet of Chemung in western Luzerne County and western Dauphin County.

In Susquehanna County the exposed part of the Chemung formation is about 380 feet thick and consists principally of fossiliferous olive-green shale and sandstone, with some red shale, brown sandstone, and thin beds of conglomerate.

Ground-water conditions.—The Chemung formation is of sufficient thickness to be classed as a water-bearer only in Susquehanna County and northern Wyoming County, where it yields small to moderate supplies of rather poor water. Some of the waters are hard and some contain hydrogen sulphide. Brackish or salty water is obtained from some of the wells, as described on pages 263 and 291.

PORTAGE GROUP

General features.—The Portage group crops out in all counties in the area, except the four northern counties of Susquehanna, Wayne, Wyoming, and Lackawanna, and includes all marine beds between the underlying Hamilton formation and the overlying marine Chemung formation or, where the marine Chemung is absent, the Catskill continental group. The nonmarine beds of Portage age are included with the Catskill.

Willard⁴⁰ has subdivided the Portage group in Pennsylvania into two formations, each comprising several members. His Fort Littleton formation includes, in this area, from top to bottom, the Trimmers Rock, Losh Run, Brallier, and Harrell members, and his underlying Rush formation includes the Burket and Tully members.

The Trimmers Rock member, the dominant member of the Portage in eastern Pennsylvania, consists principally of hard fossiliferous gray to greenish-gray massive to flaggy sandstone which contains but little shale and is therefore generally a ridge maker. The Trimmers Rock ranges in thickness from about 1,500 feet in the eastern part of the area to nearly 3,000 feet in western Luzerne County.

The Losh Run member, present only in the west-central part of the area, is a fossiliferous dark gray to brown shale, sandy in some places, which is considered to be faunally and lithologically distinct from adjacent beds. It is only about 10 feet thick.

³⁹ Willard, Bradford, Early Chemung shore line in Pennsylvania: Geol. Soc. America Bull., vol. 45, no. 5, pp. 897-908, 1 fig. Oct. 31, 1934.

⁴⁰ Willard, Bradford, Portage group in Pennsylvania: Geol. Soc. America Bull., vol. 46, pp. 1195-1218, pls. 94-95, 2 figs. Aug. 31, 1935.

The underlying Brallier member, present only in Northumberland and Dauphin Counties, consists of fine-grained green, gray-green, or gray shale which contains fragments of vegetation but very few fossils. It is considered by Willard⁴¹ to be the off-shore equivalent of the Trimmers Rock sandstone which it completely displaces to the west along the Allegheny Front. The Brallier is only 100 to 200 feet thick where it is present in the area.

The underlying Harrell shale is a fossiliferous fine dark gray to nearly black somewhat platy shale, and is likewise present only in the west-central part of the area where it is perhaps 150 feet thick in some places. In the early reports the Harrell and Burket members were called the "Genesee shale."

The underlying Burket member, present in Portage outcrops except northeast of Carbon County, consists of 40 feet or more of thin black fissile shale which is sparingly fossiliferous.

The lowermost member, the Tully limestone, which was first definitely discovered to be present in this area by Willard,⁴² varies from a hard, gray limestone with a conchoidal fracture and dark shale partings to platy limestone and calcareous shale. It is about 10 feet thick in eastern Northumberland County but is not known to be present elsewhere in the area although Willard⁴³ has found a Tully fauna in the base of the Trimmers Rock sandstone in Monroe County.

The entire Portage group, dominated in this area by the Trimmers Rock sandstone, ranges in thickness from about 1,500 to 3,100 feet, the maximum being in western Luzerne County.

Ground-water conditions.—Since the individual members of the Portage group have not been mapped separately in this area, no attempt was made to classify wells according to the separate parts of the group. The Portage yields small but generally adequate supplies of potable water to wells of moderate depth. The water is generally of good quality, but in some places it is hard and contains hydrogen sulphide. A view of the sandy portion of the Portage is shown in Plate 5-B.

MIDDLE DEVONIAN SERIES

HAMILTON FORMATION AND MARCELLUS SHALE

General features.—The Hamilton formation underlies the Portage group and is in turn underlain by the Marcellus shale. Recently Willard and Cleaves⁴⁴ included these two formations together under the term Hamilton group. The beds previously included in the Hamilton formation in this area were subdivided into their New York equiva-

⁴¹ Willard, Bradford, op. cit., p. 1199.

⁴² Willard, Bradford, A Tully limestone outcrop in Pennsylvania: *Pennsylvania Acad. Sci. Proc.*, vol. 8, pp. 57-62, 1 fig. 1934.

⁴³ Willard, Bradford, op. cit., p. 1212.

⁴⁴ Willard, Bradford, and Cleaves, A. B., Hamilton group of eastern Pennsylvania: *Geol. Soc. America Bull.*, vol. 44, pp. 757-782, 2 figs. Aug. 31, 1933.

lents, the Moscow, Ludlowville, and Skaneateles formations, underlain by the Marcellus formation. Later in studying the Hamilton group to the west, Willard ⁴⁵ found that the three upper formations could not be readily distinguished in and beyond the Susquehanna valley so they were included as facies of a new formation—the Mahantango formation, underlain by the Marcellus. For simplicity and to avoid confusion in the identification of well horizons, the older term Hamilton formation is retained in this report as the equivalent of the Moscow, Ludlowville, and Skaneateles in the east, and the Mahantango in the west. The Hamilton and Marcellus formations crop out in the same areas as the overlying Portage group.

In the long continuous outcrop along the southern boundary of the area, the Hamilton formation is 1,100 to 1,600 feet thick and consists in the eastern part of alternating beds of fossiliferous olive-gray to dark gray sandy shale and sandstone, with local thin beds of calcareous shale, coquinite, coral limestone, and concretions. It becomes more sandy toward the west until at the Susquehanna River near Rockville it is dominated by the Montebello sandstone, more than 1,000 feet thick, consisting of fossiliferous coarse sandstone and dark shaly sandstone with plant remains. In Pike and Monroe Counties the Marcellus is 700 to 880 feet thick and consists of fossiliferous gray to black shale, finely sandy in some places. In some places the Marcellus contains pyrite which on oxidation yields sulphurous iron waters. These waters have deposited bog iron ore, which is mined in some places for mineral paint. The thinning of the Marcellus at and near the Susquehanna River is discussed below.

In Columbia, Luzerne, and Montour Counties and in northern Northumberland County the Hamilton is about 1,100 feet thick and consists chiefly of bluish-gray to brownish sandy shale and some sandstone, locally with thin bluish-gray impure fossiliferous limestone. In this region the Marcellus consists of about 400 feet of fossiliferous black, gray, and dark-blue fissile shale.

In southern Northumberland County the Hamilton is sandy as it is in Dauphin and Perry Counties, and at Dalmatia, where the Hamilton is about 1,100 feet thick, the lower 400 feet consists of the hard, coarse Montebello sandstone (see Plate 7-A). The Marcellus shale is about 500 feet thick at Dalmatia, and contains near the middle about 240 feet of hard, massive, coarse, olive-gray sandstone and fine-grained, light gray sandstone, which Willard ⁴⁶ has called the Turkey Ridge and Mexico sandstones.

⁴⁵ Willard, Bradford, Hamilton group of central Pennsylvania: Geol. Soc. America Bull., vol. 46, pp. 195-224, pl. 19, 3 figs., Feb. 28, 1935.

——— Hamilton group along the Allegheny Front in Pennsylvania: Geol. Soc. America Bull., vol. 46, pp. 1275-1290, 2 figs., Aug. 31, 1935.

⁴⁶ Willard, Bradford, Hamilton group of central Pennsylvania: Geol. Soc. America Bull., vol. 46, p. 203, 1935.

Over most of the area included in the Susquehanna Valley the Marcellus rests disconformably on the underlying Onondaga formation, but east of Dauphin the contact is transitional. Locally, in the absence of some of the underlying formations, the Marcellus may rest disconformably on the Oriskany sandstone or the Helderberg limestone. On the north side of Kittatinny Mountain, in Dauphin County, the Marcellus is quite thin and rests directly on rocks of Silurian age. Thus, about 1,000 feet of beds are absent, including most of the Marcellus, all of the Onondaga formation, Oriskany sandstone (in part), and Helderberg limestone, and possibly part of the Cayugan series. The missing strata are present to the east in Lebanon County and to the west in Perry County. Two theories⁴⁷ have been postulated to account for the missing beds—either that they were never deposited, or that the intense folding has produced a strike fault shoving the Marcellus beds directly against the Silurian.

Ground-water conditions.—The Hamilton and Marcellus do not crop out in Lackawanna, Susquehanna, Wayne, and Wyoming Counties, and are unimportant as sources of ground water in Dauphin County. In the remainder of the area shallow drilled wells in these formations generally yield small but reliable supplies of good water. The Hamilton generally yields more water than the Marcellus, because in most places the Marcellus consists largely of shale, whereas the Hamilton contains sandstone. In some places moderately large supplies are obtained from deeper wells encountering sandstone. In Carbon, Monroe, Pike, and Schuylkill Counties these formations generally yield water of good quality, but in Columbia, Montour, Northumberland, and Luzerne Counties the water is likely to be hard and high in sulphate and may give off hydrogen sulphide. However, the water obtained from these formations is generally satisfactory for domestic use.

ONONDAGA FORMATION

General features.—As recently defined by Willard,⁴⁸ “the Onondaga formation in Pennsylvania, includes all strata between the overlying Marcellus shale and the underlying Oriskany sandstone,” and “because of its faunal and stratigraphic connections with the overlying beds, the Onondaga formation in Pennsylvania is now assigned to the position of lowest formation of the Hamilton group of the Middle Devonian.” Willard includes the Esopus shale with the Onondaga. It crops out beneath the Marcellus along the southern border of the area at the tri-state monument in Pike County, from Monroe County to Lebanon

⁴⁷ See: Lesley, J. P., *Pennsylvania Geo. Survey Final Rept.*, pt. 2, p. 1181. 1892.
Swartz, F. M., *The Helderberg group from central Pennsylvania to southwestern Virginia: Pennsylvania State College, Mineral Industries Exper. Sta., Bull.* 4, p. 15, 1929.
Willard, Bradford, *Oriskany at Susquehanna Gap, Pennsylvania: Geol. Soc. Amer. Bull.*, vol. 42, p. 706. 1931.

⁴⁸ Willard, Bradford, *The Onondaga formation in Pennsylvania: Jour. Geology*, vol. XLIV, no. 5, pp. 578-603, 1936.

County, is absent in Dauphin County (see p. 57), crops out in southern Northumberland County, but is absent in the west-central part of the area except in west-central Luzerne County.

In the eastern part of the area a cherty limestone member overlies the Esopus shale member, and in the west-central part of the area a non-cherty limestone member overlies a calcareous shale member.

The outcrop of the cherty limestone member (the †“Corniferous” or so-called Upper Helderberg limestone of the Pennsylvania Second Geological Survey reports)^{48a} parallels the Delaware River along the entire New Jersey-Pike County line, entering Pennsylvania at the tri-state marker in Pike County and at Wallpack Bend, at the junction of Pike and Monroe Counties with New Jersey. In Monroe County the cherty limestone is nearly 200 feet thick near Stroudsburg and 250 feet at the New Jersey line. In this region the member is similar to that in New York⁴⁹ and consists of successive layers of fossiliferous dark-gray limestone 1 to 10 feet thick containing considerable clay. Numerous black flint or chert nodules ranging in diameter from 1 inch to 1 foot are embedded in the limestone. The cherty limestone thins rapidly westward and is not definitely known southwest of the Lehigh River in Carbon County where it is only 5 feet thick.

The underlying Esopus shale member is absent from Pike County and enters Pennsylvania at Wallpack Bend in Monroe County. It is 315 feet thick at Wallpack Bend, 250 feet thick opposite the Delaware Water Gap, but thins rapidly westward to from 4 to 10 feet in Carbon County and is not identified beyond that point. It consists of dark ash-gray, tough, hard sandy shale, which in some beds is slightly calcareous and which has pronounced slaty cleavage at right angles to the bedding. It is very resistant and forms large areas of bare rocks. It was formerly known as the †Cauda-galli grit but was later correlated with the Esopus shale of New York by Kindle.⁵⁰ On Plate 1 the Esopus shale member is mapped with the underlying Oriskany sandstone.

The noncherty limestone, the upper member of the Onondaga in central Pennsylvania, appears first in Carbon County as 20 feet of “hydraulic cement rock,” beneath the thin cherty member. It is 7 feet thick in Lebanon County. In Northumberland County it is the †Selinsgrove lower limestone of I. C. White.⁵¹ At Selinsgrove Junction the non-cherty limestone member is 65 feet thick and consists of a series of hard light-gray, rather impure limestone layers separated by thin shaly beds. It is 75 feet thick at Dalmatia, 6 miles to the south. The non-

^{48a} A dagger (†) preceding a geologic name indicates that the name has been abandoned or rejected for use in classification in publications of the U. S. Geological Survey. Quotation marks, formerly used to indicate abandoned or rejected names, are now used only in the ordinary sense.

⁴⁹ Kindle, E. M., The Onondaga fauna of the Allegheny region: U. S. Geol. Survey Bull. 508, pp. 23-25, 1912.

⁵⁰ Kindle, E. M., Op. cit., p. 24.

⁵¹ White, I. C., Pennsylvania Geol. Survey, 2d Ser., Rept. G-7, p. 80, 1883.

cherty member dies out east of Northumberland County, but may be present as a few feet of beds in west-central Luzerne County.

The lower member in the west-central part of the area, the calcareous shale member, consists of gray calcareous shale containing some limestone and grading upward into the noncherty limestone member. It is 140 feet thick at the Selinsgrove anticline, where it was called †Selinsgrove shale by I. C. White.

This is probably all Onondaga limy shale. Fossils formerly unknown, have been found in it.

Ground-water conditions.—The Onondaga formation is of very little importance as a source of ground water in northeastern Pennsylvania. In Monroe County the cherty limestone member yields small to moderately large supplies of water, which is slightly hard but softer than typical limestone waters. (See p. 175.) Large yields are obtainable only when one or more water-filled solution channels are encountered. The cherty limestone supplies several wells across the Delaware River in New Jersey (p. 231). In the rest of the area the upper member is thin or absent, and where it is thin nothing is known of its water-bearing properties. Very little is known as to the water-bearing properties of the Esopus shale member. It may supply a few domestic wells in Monroe County, where its outcrops are large but very hilly and rugged. In Monroe County its thick beds of sandy shale appear to be permeable enough to yield adequate supplies of water, but no data are available to confirm this inference. The lower calcareous shale member is thought to supply one well in Northumberland County (p. 200).

LOWER DEVONIAN SERIES

ORISKANY SANDSTONE

General features.—The Oriskany sandstone crops out in a long narrow belt through Monroe, Carbon, and Schuylkill Counties and in part of Lebanon County. It is absent from Dauphin County but is well exposed on several anticlines in Northumberland, Montour, and Columbia Counties. The rocks that make up the Oriskany change so radically in character and thickness in relatively short distances that separate descriptions are necessary for most of the counties. Normally the Oriskany is disconformable below the Onondaga formation and above the Helderberg limestone, but exceptions to this are noted below.

In New Jersey near the eastern extremity of Pike County, Pa.,⁵² the Oriskany consists of about 50 feet of calcareous cherty shales, without any sandstone or conglomerate, which is characteristic of the Oriskany in most places. At the eastern line of Monroe County the formation consists of a cherty sandstone bed 8 to 10 feet thick, which thickens to-

⁵² White, I. C., The Geology of Pike and Monroe Counties, Pennsylvania: Geol. Survey, 2d Ser., Rept. G-6, pp. 122-127, 1882.

ward the southwest, becoming about 56 feet thick at the Delaware Water Gap and about 175 feet at the western line of the county. In the vicinity of Stroudsburg the Oriskany consists, at the top, of thick-bedded hard coarse-grained calcareous sandstone, somewhat fossiliferous, followed by alternating layers of coarse sandstone or conglomerate and dark chert. In the western part of Monroe County the Oriskany consists of about 175 feet of massive coarse-grained quartz sandstone, which dips at a steep angle and forms a steep ridge covered with fragments of the disintegrated sandstone.

At the Lehigh River in Carbon County the Oriskany outcrop is repeated three times, the northern outcrop forming the north rim of an overturned anticline, and the southern outcrops skirting a U-shaped compressed syncline. Here the Oriskany consists mainly of massive calcareous sandstone and conglomerate, with some sandy shale and chert. At the outcrop the calcareous cement has been leached out, so that the sandstone crumbles readily. According to White⁵³ the thickness of the Oriskany in Carbon County is about 340 feet, but according to Swartz⁵⁴ it is more than 268 feet and may be nearly 400 feet.

In Schuylkill County near Auburn the Oriskany (?) has thinned to a 1½-foot bed of conglomerate lying unconformably on the Bloomsburg red beds, and farther northeast, at Rausches, the Oriskany (?) overlies unconformably a thin tongue of the Bossardville limestone.⁵⁵ Farther to the southwest, in a quarry about half a mile east of Summit, the Oriskany has again thickened and resembles the Oriskany on the Lehigh River. At Swatara Gap, still farther southwest, the section is similar to that near Auburn. The Oriskany appears to die out southwest of Swatara Gap and is absent in Dauphin County. (See p. 57.)

At Dalmatia, in southern Northumberland County, the Oriskany consists of 50 feet of massive sandstone containing considerable chert.⁵⁶ Farther north, on the south side of the anticlinal axis at Selinsgrove Junction, the Oriskany formation has changed in character and is about 55 feet thick, as measured by Reeside.⁵⁷

North of the North Branch of Susquehanna River the Oriskany crops out on both sides of the Montour anticline through Northumberland and Montour Counties and as far east as Bloomsburg, Columbia County, but appears to be absent between Bloomsburg and Berwick.⁵⁸ It also crops out around the Milton anticline, in northern Northumberland, and

⁵³ White, I. C., *op. cit.*, pp. 80-81.

⁵⁴ Swartz, F. M., The Helderberg group from central Pennsylvania to southwestern Virginia: Pennsylvania State College, Mineral Industries Exper. Sta., Bull. 4, p. 26, 1929. Also Penna. Acad. Sci. Proc. vol. III, pp. 75-89, 1929.

⁵⁵ Swartz, F. M., *op. cit.*, pp. 26-27.

⁵⁶ White, I. C., The geology of the Susquehanna River region: Pennsylvania Geol. Survey, 2d ser., Rept. G-7, pp. 370-372, 1883.

⁵⁷ Reeside, J. B., Jr., The Helderberg limestone of central Pennsylvania: U. S. Geol. Survey Prof. Paper 108, p. 221, 1918.

⁵⁸ White, I. C., *op. cit.*, pp. 85-86.

Montour Counties. In this northern region the Oriskany scarcely resembles that of the other localities mentioned above. In some places it is a mere mass of impure chert grading laterally into cherty, rotten dirty-yellow sandstone. The thickness of the Oriskany in this region is 40 feet.

Ground-water conditions.—In Monroe and Carbon Counties, where the Oriskany is well developed, it appears to be a highly permeable sandstone, but owing to the rugged nature of its steeply dipping outcrops, it supplies only a very few wells, so that the maximum yields obtainable are not known. In Montour and Northumberland Counties, where it is thin and calcareous, it supplies a few domestic wells with hard water. In the remainder of the area it is absent or too thin to be of importance.

HELDERBERG LIMESTONE

General features.—The Helderberg limestone (†Lower Helderberg limestone of Pennsylvania Second Geological Survey reports) is the lowermost formation of the Devonian system and either conformably or unconformably overlies the Cayuga group of the Silurian system. The †Lower Helderberg as described by White⁵⁹ and shown on plate 1 erroneously includes the Tonoloway limestone, the upper formation of the Cayuga group to the west, and the equivalent Bossardville limestone, the upper formation of the Cayuga group, to the east.

The classification and correlation of the Helderberg have long been a subject of dispute. The most recent studies on the subject by Reeside⁶⁰ and Swartz⁶¹ correlate the old stratigraphic terms of I. C. White with those in current use in other regions, and these new names will be used in the following descriptions.

Like the other Lower Devonian formations, the Helderberg undergoes great lateral changes in thickness and character and is hundreds of feet thick in some places and absent in others. The areal distribution of the Helderberg is essentially the same as that of the Oriskany already described, except that the Helderberg is also present around Montour Ridge between Bloomsburg and Berwick.

According to Swartz⁶² the Helderberg is 415 feet thick in Monroe County and is divisible from top to bottom into the following members: Stormville shale of I. C. White, New Scotland limestone, Coeymans limestone, and Keyser limestone. The shale, which is 247 feet thick, consists of dark-gray arenaceous shale, with some shaly sandstone and some chert lenses, underlain by beds of dark- and light-gray shale, gray calcareous shale, and some shaly limestone. In some of the beds the

⁵⁹ White, I. C., Pennsylvania Geol. Survey, 2d ser., Repts. G-6, 1882; G-7, 1883.

⁶⁰ Reeside, J. B., Jr., op. cit., pp. 185-225.

⁶¹ Swartz, F. M., op. cit.

⁶² Swartz, F. M., op. cit., pp. 23-25.

bedding is obliterated by shaly cleavage. According to Butts⁶³ this shale and the underlying Stormville conglomerate of I. C. White in Monroe County should be assigned to the Oriskany sandstone, forming a lower division equivalent to the Shriver chert of Maryland. The New Scotland limestone, 35 feet thick, consists of medium- to thick-bedded dark-blue dense and shaly limestones, with some interbedded chert and a few thin beds of gray soft shale. The Coeymans limestone, 41 feet thick, is composed of hard blue-gray sandy, somewhat crystalline limestone underlain by massive blue crystalline crinoidal limestone containing some chert. The lower member, the Keyser limestone, 92 feet thick, consists of alternating beds of sandy limestone and calcareous sandstone, some conglomeratic sandstone, and a basal (?) bed of soft shaly limestone. The Helderberg contains numerous fossiliferous beds throughout its thickness.

In Carbon County the Helderberg has thinned tremendously and, according to Swartz,⁶⁴ is only 207 feet thick. Farther to the southeast, near Rausches, Schuylkill County, the Helderberg is absent and the Oriskany (?) rests uncomfortably on a thin tongue of the Bossardville limestone. Near Auburn and at Swatara Gap the Oriskany lies unconformably on the Bloomsburg red beds, both the Helderberg and the Bossardville being absent. The Helderberg is lacking in Dauphin County.

Very detailed sections were made of the Helderberg and adjacent strata in Northumberland and Montour Counties by Reeside,⁶⁵ whose measurements of the Helderberg, together with those of Swartz at Delaware Water Gap, are as follows:

Sections of the Helderberg limestone

	1	2	3	4
	Feet	Feet	Feet	Feet
New Scotland limestone member -----	21.6	57.6	¹ 110±	35
Coeymans limestone member -----	2.0	3.6	3.0	41
Keyser limestone member -----	139.8	202.3	122.5	92

¹ "Limestone and shales of undetermined age, but probably New Scotland and Oriskany."

1-3, Reeside; 4, Swartz.

1. 1 mile south of Dalmatia.

2. On south side of anticlinal axis at Selinsgrove Junction.

3. At Grovania, near Columbia-Montour County line.

4. Near Delaware Water Gap (excluding Stormville shale of I. C. White at top, 247 feet thick).

The lithologic character of the three members of the Helderberg in this region is in general similar to that in Monroe County, but on the north side of Montour Ridge and on both sides of the Milton anticlinal

⁶³ Butts, Charles, personal communication.

⁶⁴ Swartz, F. M., op. cit., p. 26.

⁶⁵ Reeside, J. B., Jr., op. cit., pp. 216-225.

axis the thickness of the Helderberg is considerably less than it is on the south side of Montour Ridge.

Reeside⁶⁶ believes that in this part of the area a part of the Stormville shale of I. C. White (included in the Helderberg by White) belongs to the Oriskany.

Ground-water conditions.—The Helderberg limestone is a source of ground water only in Columbia, Monroe, Montour, and Northumberland Counties, for it is thin, absent, or unimportant elsewhere. In Columbia County it yields moderately large supplies of medium-hard water, and the water from one well contained an excess of iron, which presumably originated in the Cayuga. In Monroe County the Helderberg is of minor importance but may supply a few domestic wells. In Montour and Northumberland Counties it yields small to large supplies of hard water and feeds numerous springs. The occurrence of ground water in the Helderberg of these two counties is discussed in some detail in the section on those counties.

SILURIAN SYSTEM

CAYUGA GROUP

General features.—The Cayuga group of central Maryland is divided from top to bottom into the Tonoloway, Wills Creek, Bloomsburg, and McKenzie formations. In northeastern Pennsylvania the presence of the Tonoloway limestone has been definitely established by Reeside⁶⁷ and Swartz⁶⁸. It is known in the eastern part of the area as the Bossardville limestone. The Poxono Island shales and limestones and Bloomsburg red shale, mapped in 1883 by White,⁶⁹ correspond respectively to the Wills Creek formation and the Bloomsburg red beds of present nomenclature. (The Bloomsburg shale has in some previous reports been treated as the lower member of the Wills Creek formation of Maryland, but it is now regarded as a distinct formation.) C. K. and F. M. Swartz⁷⁰ definitely established the presence of the McKenzie formation in the section as far east as Danville, Montour County, but not along Kittatinny or Blue Mountain, because of the thickening eastward of the Bloomsburg red beds, as described in the following quotation:⁷¹

The Bloomsburg red beds thicken eastward, being a continental deposit, representing marine formations farther west. This formation replaces in turn the Wills Creek, Bloomsburg, upper part of the McKenzie, possibly the entire McKenzie, and perhaps the lower part of the Tonolo-

⁶⁶ Reeside, J. B., Jr., *op. cit.* p. 186.

⁶⁷ Reeside, J. B., Jr., *op. cit.* pp. 217-225.

⁶⁸ Swartz, F. M., *op. cit.* pp. 22-27.

⁶⁹ White, I. C., *Pennsylvania Geol. Survey*, 2d ser., Rept. G-7, pp. 98-114, 1883.

⁷⁰ Swartz, C. K. and F. M., *Early Silurian formations of southeastern Pennsylvania: Geol. Soc. America Bull.*, vol. 42, pp. 621-662, 1931.

⁷¹ *Idem*, p. 659.

way of the west. It is continuous with the Longwood of New Jersey and the High Falls red beds of eastern New York. It is believed to be the same as the Vernon red shales of central New York and that all of these continental formations should bear one name.

The Cayuga group is exposed by the Milton anticline and underlies a large area in northern Montour and Northumberland Counties but is best exposed farther south along both sides of the Montour anticlinal ridge. Its upper part also comes to the surface at Selinsgrove Junction and Dalmatia. The total thickness of the Cayuga group in this part of the area is about 1,400 feet. The Tonoloway limestone in this region is 100-150 feet thick and consists mainly of platy, laminated limestones, with thick beds occurring locally at the top. On plate 1 the Tonoloway and Bossardville limestones are mapped with Helderberg limestone.

Below the Tonoloway occurs the Wills Creek formation (upper and middle Salina group of I. C. White) consisting of 329 feet of buff and pale-green limestone and limy shales and 407 feet of alternating red and greenish shales and limestones.

The Wills Creek is underlain by the Bloomsburg red beds, a very persistent and easily distinguished formation consisting of dark-red sandy shale with a few thin layers of bright-green shale and a few beds of red sandstone. Its thickness ranges from 404 to more than 800 feet in this region, and in some places it forms steep bluffs and cliffs in contrast to the valleys formed by the softer Wills Creek formation.

Between the Bloomsburg above and the Clinton formation below is a group of rocks composed of red and greenish shale and gray calcareous shale, with some dark blue limestone. These beds were mapped as Clinton by I. C. White but have been definitely correlated with the McKenzie formation by C. K. and F. M. Swartz,⁷² who found them to be 156.5 feet thick near Danville.

The Cayuga group crops out in the valley just north of Kittatinny Mountain along the southern border of the area described in this report. In this region the Bloomsburg red beds are the predominant formation of the Cayuga group and they thicken eastward, gradually replacing nearly all of the other Cayuga formations.

In this part of the area the Bossardville limestone consists of dark-blue limestone, massive in most places and laminated in some places. The exposed part of the Bossardville is 73 feet thick at the Delaware Water Gap and 77 feet thick on the Lehigh River. It is absent west of Carbon County except for a thin tongue near Rausches in Schuylkill County.

In Carbon and Monroe Counties the Poxono Island shale of I. C. White, consisting of about 200 feet of greenish-gray and variegated calcareous shale represents the Wills Creek. The Wills Creek is absent west of Carbon County.

⁷² Swartz, C. K. and F. M., *op. cit.*, pp. 629, 630.

In this part of the area the Bloomsburg consists of red shale and sandstone with beds of brown calcareous shale, green shale, and hard greenish-gray sandstone. Its thickness increases from 507 feet at the Susquehanna River to 1,586 feet at Swatara Gap only 23 miles to the east. It is 1,800 feet thick in Schuylkill County, and may be nearly 2,000 feet thick in Monroe County.

At Swatara Gap 110 feet of massive gray and greenish-gray sandstone may belong to either the Clinton formation or the McKenzie formation.

Fossils are found in most of the Cayuga formations in the western part of the area, particularly along Montour Ridge, but they become scarcer toward the east.

Ground-water conditions.—The Tonoloway limestone of Columbia, Montour, and Northumberland Counties is very similar in its water-bearing capacity to the overlying Helderberg limestone, described on page 63. The Bossardville limestone of Monroe County is of less importance as a water bearer. The Tonoloway (together with the overlying Helderberg) and the underlying calcareous portion of the Cayuga group underlie a large area of northern Montour and Northumberland Counties, where they form the only typical limestone region in the area, as described in detail in the section on those counties. Here the thin-bedded limestones and shales beneath the Tonoloway yield moderate to large supplies of very hard water and supply numerous springs.

The Bloomsburg red beds are an important water-bearing formation in Carbon, Columbia, Montour, Northumberland, and Schuylkill Counties and to some extent in Dauphin County. They yield small to large supplies of water, which is almost invariably very soft and low in dissolved mineral matter. They are very similar to the Mauch Chunk shale, and where large yields are reported, as in Carbon County, the water probably comes from beds of sandstone. The Bloomsburg would probably yield adequate supplies of soft water in Monroe County, but data are lacking.

CLINTON FORMATION

General features.—According to Butts,⁷³ the Clinton formation in this area presents two facies—what may be regarded as a normal facies, with fossils and iron ore, occurring in Columbia, Montour, and Northumberland Counties, and a thicker facies, without fossils or ore but with more sandstone, occurring along the summit and western slope of Kittatinny Mountain. C. K. and F. M. Swartz⁷⁴ were successful in tracing the Silurian sequence of Maryland as far east as the Susquehanna River and with less certainty as far east as Swatara Gap but reported that farther east the Clinton becomes more sandy and conglomeratic and

⁷³ Butts, Charles, personal communication.

⁷⁴ Swartz, C. K. and F. M., *op. cit.*, pp. 654-659.

unites with the underlying Tuscarora sandstone to form the Shawangunk conglomerate at the Delaware Gap.

The Clinton formation of Columbia, Montour, and Northumberland Counties is continuous with that of central Pennsylvania and Maryland where its limits are well defined by fossil evidence, and is conformable on the Tuscarora sandstone. In this area its hard, resistant strata have been folded into an anticlinal ridge (Montour Ridge) and have been cut through by streams at Danville and Bloomsburg and by Susquehanna River at Danville and Northumberland. C. K. and F. M. Swartz⁷⁵ have split the Clinton into what they call "Rochester" and "Rose Hill" formations and classify the Keefer sandstone as a member of the Rochester. Their Rochester is here 89.5 feet thick and consists of 44 feet of fossiliferous dark-blue limestone interbedded with gray calcareous shale, terminated below by their Keefer member, consisting of 45.5 feet of fossiliferous hard gray calcareous sandstone with some interbedded shale. Their Rose Hill is here 867 feet thick, and the exposed part consists chiefly of greenish shale and very fossiliferous greenish-blue limestone. Although fossil iron ore is not mentioned in their section, it is known to occur at other nearby localities, and two "veins" of ore 3 to 4 and 10 to 12 inches thick separated by shale crop out along Fishing Creek.

The Clinton occupies the north slope and in places the crest of Kitatinny Mountain, which forms the southern boundary of the area, and conformably overlies the Tuscarora sandstone. According to Schuchert,⁷⁶ from Delaware Water Gap eastward the Clinton and Tuscarora together form the Shawangunk conglomerate. The Clinton is well exposed in several water gaps between those of the Susquehanna and Delaware.

Between the Susquehanna and Swatara gaps C. K. and F. M. Swartz⁷⁷ divide the Clinton into Rochester formation (in which they include the Keefer sandstone) and Rose Hill formation, but east of the Susquehanna River these subdivisions lose their calcareous beds, become increasingly barren of fossils, and become thicker and more sandy with the introduction of several zones of hard red iron sandstones in the lower part. At Lehigh Gap the Clinton is 1,093 feet thick and consists predominantly of hard greenish-gray, brown, and red sandstone, with some red and olive-green shale and a few beds of hard iron sandstone. At the Delaware Gap the Shawangunk conglomerate is about 1,823 feet thick. Stose⁷⁸ believes that of this thickness the lower 200 to 225 feet of heavy sandstone and conglomerate represent the Tuscarora and that the overlying beds represent the Clinton. In this region the Clinton is somewhat thicker and coarser than it is to the west and contains some

⁷⁵ Swartz, C. K. and F. M., *op. cit.*, pp. 629-632.

⁷⁶ Schuchert, Charles, *Silurian formations of southeastern New York, New Jersey, and Pennsylvania*: *Geol. Soc. America Bull.*, vol. 27, pp. 545-546, 1916.

⁷⁷ Swartz, C. K. and F. M., *op. cit.*, pp. 631-638.

⁷⁸ Stose, G. W., *Unconformity at the base of the Silurian in southeastern Pennsylvania*: *Geol. Soc. America Bull.*, vol. 41, p. 654, 1930.

beds of conglomeratic sandstone. Many of the greenish sandstones have been cemented to quartzite and are perhaps the hardest and most resistant rocks in northeastern Pennsylvania.

Ground-water conditions.—The Clinton is a very good water-bearing formation in Monroe County, where it yields moderate to large supplies of good water to deep wells, many of which flow. It would doubtless yield adequate supplies of water all along Kittatinny Mountain and along Montour Ridge, but owing to the rugged, uninhabited character of its outcrop areas it has not been exploited elsewhere, except possibly along the Susquehanna River in Dauphin County.

TUSCARORA SANDSTONE

General features.—The Tuscarora sandstone underlies the Clinton formation and is the lowermost formation of the Silurian in northeastern Pennsylvania. It is partly exposed by stream cuts along Montour Ridge and fully exposed in water gaps along the south slope of Kittatinny Mountain. Between the Delaware Water Gap and Manada Gap it rests unconformably on the Martinsburg shale, but west of Manada Gap it overlies the Juniata formation, which in turn rests unconformably on the Martinsburg, through the absence of the Oswego sandstone. Along the southern outcrop the Tuscarora was mistakenly identified with the sandstone of Nittany Valley called by the Second Pennsylvania Survey the "Oneida conglomerate." This sandstone is now known to be the Oswego sandstone, which in Nittany Valley underlies the Juniata (Red Medina of the Second Survey). The Oswego is not present in this area, and the Juniata is present only west of Manada Gap.

The Tuscarora sandstone is made up of a basal coarse quartz conglomerate, which in places contains pebbles of black shale, and beds of hard white sandstone, quartzite, and conglomerate. The Tuscarora ranges in thickness from 100 to more than 400 feet.

Ground-water conditions.—The water-bearing properties of the Tuscarora sandstone in this area are unknown, because no wells were observed which penetrated it, and as its outcrop areas are rugged and uninhabited, it will probably never be extensively exploited for water.

UNCONFORMITY AT THE BASE OF THE SILURIAN

The contact relations between the Silurian and Ordovician systems have been thoroughly investigated by Stose,⁷⁹ who concludes that:

The unconformity at the base of the Silurian in eastern Pennsylvania, New Jersey, and southwestern New York, which represents the Taconic revolution of southeastern New York, extends southwestward to the Susquehanna River gap but not to the southern border of Pennsylvania, nor to the central part of the State. In Pennsylvania this unconformity consists of an overlap of the basal conglomerate of the Tuscarora sandstone

⁷⁹ Stose, G. W., op. cit., pp. 656-657.

and its representative in the east, the lower part of the Shawangunk conglomerate, on the folded and eroded Martinsburg shale, the sandstone resting in a large part of the area on the lower member of the shale, from which the upper sandy member had been eroded previously.

The Juniata formation, of red shale and sandstone, and the still lower Oswego sandstone, normally succeeding the Martinsburg shale, are both absent, leaving a hiatus of 2,500 feet at least between the Martinsburg and Tuscarora. There is no apparent angular discordance at any of the gaps, except at the Schuylkill Gap, where the Tuscarora sandstone is vertical and rests against nearly horizontal Martinsburg shale. [See pl. 3-B.]

ORDOVICIAN SYSTEM

JUNIATA FORMATION

General features.—The Juniata formation, of Upper Ordovician age,⁸⁰ underlies the Tuscarora sandstone at Susquehanna Gap and is unconformable on the Martinsburg shale. The Juniata is not present along Kittatinny Mountain east of the Susquehanna Gap and is not found in Manada Gap or in any section farther east.⁸¹

At the Susquehanna Gap the strata are overturned, and the Juniata is exposed at the south foot of Kittatinny Mountain, dipping 70° S., overturned, and lying on top of the younger Tuscarora sandstone. The Juniata is here 68 feet thick and consists chiefly of red sandstone with some conglomerate.

Ground-water conditions.—The Juniata formation is exposed in this area only in Dauphin County, where its water-bearing properties are unknown, as no wells were observed along its outcrop.

⁸⁰ The Juniata is classed as Silurian by the Pennsylvania Topographic and Geologic Survey.

⁸¹ Stose, G. W., *op. cit.*, p. 641.

COUNTY DESCRIPTIONS

In the following pages the geology and ground-water conditions are described by counties in alphabetic order, with tables of water-bearing formations, public supplies using ground water, representative drilled wells, and chemical analyses of ground waters.

The drilled wells and a few dug wells shown on the maps of well locations are numbered from 1 to 1161 in order of counties from north (Susquehanna County) to south (Dauphin County). In each county the wells are numbered consecutively from north to south and are tabulated by townships. Wells located in boroughs that are separate political units are arbitrarily classified in the nearest township. The same numbers are used to identify the chemical analyses of waters for each county.

The information pertaining to many of the domestic supplies and a few of the industrial supplies listed in the accompanying well tables was obtained from well drillers. These wells were located on topographic maps from the descriptions given by the drillers. It was not possible in the time available to visit each well in the field, and therefore some of the wells may not be accurately located, although most of the locations are believed to be correct. The altitudes shown are taken from the nearest contour on the topographic maps unless otherwise designated.

It was not generally possible to make measurements of depths and water levels, because most of the wells listed are drilled wells covered with pumps. Most of the data are taken from statements of drillers or owners. Only a few of the well drillers have kept written records, and most of these records are incomplete. The figures on depth to water level are probably the least accurate of all given in the tables, as most of the drillers and well owners relied on memory in supplying this information.

The data pertaining to the industrial and public supplies were taken chiefly from written records and are therefore more accurate than the figures given for domestic supplies.

Data on depth and thickness of water-bearing beds are not given in all the tables, as they were not available in many of the counties.

In describing the location of wells, the nearest town is given rather than the post office address of the owner.

The tables of public supplies include only those supplies which utilize ground water either as a sole source or as an auxiliary source.

The figures given for population are those of the census of 1930.

CARBON COUNTY

GENERAL FEATURES

(Area 406 square miles; population 63,380)

Carbon County is in the southeast corner of the area described in this report. In 1930 there were four towns in Carbon County having 5,000 or more inhabitants—Lansford, 9,632; Palmerton, 7,678; Lehighton, 6,490; and Summit Hill, 5,567. Only a part of the county is adapted to agriculture. In 1929 there were 73 manufacturing establishments with annual products valued at \$5,000 or more, and in 1930 there were 5 anthracite mines. Nearly all of the industrial development is along the Lehigh River.

The high plateau called "Pocono Mountain," in Monroe County, extends southwestward into Carbon County, where it forms Pohopoco and Broad Mountains and several smaller ridges, such as Mauch Chunk Ridge. Lake Mountain, more than 2,220 feet above sea level, is the highest point in the county. Kittatinny Mountain, joining the southern boundary of the county, has a nearly uniform altitude of about 1,500 feet. Lehigh River at its lowest point in the Lehigh Gap is 393 feet above sea level. The total relief is therefore about 1,800 feet.

Except for several small areas in the western part of the county, which drain into tributaries of Schuylkill River, Carbon County is drained entirely by Lehigh River, which flows southward through the middle of the county in a steep-sided gorge that cuts across all the mountains and in many places is 1,000 feet deep.

GEOLOGY AND GROUND WATER

GENERAL SECTION

The northern part of Carbon County, including two-thirds of Kidder Township and a small part of Lehigh Township, lies north of the Wisconsin drift border and was covered by ice during the last glaciation. More than half of the county lies north of the Illinoian drift border, and the entire county lies far north of the Jerseyan drift border. (See pl. 1.) The only extensive deposits of drift that were noted south of the Wisconsin drift border are those in the valley of Aquashicola Creek.

The rock formations exposed in Carbon County range in age from the post-Pottsville formations, of Pennsylvanian age, down to the base of the Tuscarora sandstone, of early Silurian age. The Martinsburg shale, of Upper and Middle Ordovician age, is exposed at or near the county line at the Lehigh Water Gap. The youngest rocks are exposed in a narrow syncline, the Panther Creek coal basin, which lies between Nesquehoning and Pisgah Mountains, and in the Beaver Meadow syncline, near the Luzerne County line. The oldest formation, the Tuscarora, crops out along Kittatinny Mountain at the county line.

Generalized section for Carbon County

Geologic unit	Maximum thickness exposed Feet	Character of rocks	Ground-water conditions
Glacial drift	150±	Uneven deposits of clay, sand, quicksand, and gravel. Wisconsin 150 feet thick in places, Illinoian 50 feet thick in places, Jerseyan drift doubtfully present.	North of Wisconsin border, drift yields small supplies to a few wells. Illinoian (?) drift, in Aquashicola Creek Valley, yields large supplies of potable water.
Post-Pottsville formations	975±	Coal, sandstone, and conglomerate.	Unimportant as source of potable water; only 1 well recorded.
Pottsville formation	1,000±	Coarse conglomerate and hard sandstone. Some red shale near base. Small, rugged outcrops.	Unimportant in Carbon County; no wells recorded.
Mauch Chunk shale	2,160±	Chiefly red sandstone and red shale, some friable yellow sandstone near base.	Shallow wells yield small supplies; wells 150 to 600 feet deep yield large supplies; many flowing wells. Water is of excellent quality.
Pocono sandstone	750±	Hard gray and red sandstone, yellow, green, and gray shale, and hard coarse quartz conglomerate.	Yields small supplies to shallow wells; would probably yield large supplies to deep wells. Water of excellent quality.
Catskill group	6,100±	Red and green sandstone and shales, and some conglomerate.	Yields small to moderate supplies to wells less than 150 feet deep; would probably yield larger supplies to deep wells. Water of excellent quality.
Portage group	1,400±	Chiefly dark shales, with thick beds of sandstone near middle and near the base. Black shale at base.	Yields small to moderate supplies of potable water to shallow domestic wells. Water of good quality.
Hamilton formation	1,400±	Dark-gray shale, dark hard fossiliferous slate, and flaggy sandstone.	Yields small supplies to shallow domestic wells. Deep wells, particularly those encountering sandstone, may obtain large supplies. Water of good quality.
Marcellus shale	800±	Dark and gray shale.	Yields small supplies of water of good quality to shallow wells.
Onondaga formation	50±	5 feet of cherty limestone underlain by 20 feet of "hydraulic cement" limestone, paint ore, and clay.	No wells known to exist. Paint ore tunnels yield water high in iron.
Oriskany sandstone	268-400?	Chiefly massive coarse calcareous sandstone.	Unimportant, rugged uninhabited outcrop area; only one well observed.
Helderberg limestone	55-207	Sandy calcareous shale, sandstone, and impure limestone.	Unimportant; small outcrop; no well data available.
Cayuga group	¹ 2,000±	Bossardville limestone, Wilfs Creek shale (thin-bedded calcareous shale and limestone); Bloomsburg red beds (red and olive-green shale).	Bloomsburg red beds yield large supplies of excellent water to deep wells; no data on other formations.
Clinton formation	1,090	Hard red, green, and white sandstone; hard white sandstone and conglomerate; red and olive-green shale.	No well data available; known to be water-bearing in Monroe County.
Tuscarora sandstone	457	Hard conglomerate of quartz and black shale pebbles, overlain by hard white sandstone, conglomerate, and sandy shale.	No wells.

¹ A large part of the Cayuga is not exposed.

STRUCTURE⁸²

The geologic structure of Carbon County differs from that of adjoining counties in that it is complicated by major faulting as well as by folding. In the northern part of the county there are several folds which form the northeastern extension of the folds in the Hazleton coal basin, the southern part of which is the Beaver Meadow syncline. The northeastern part of the county is capped by nearly horizontal strata of Catskill sandstone. Broad Mountain is an anticlinal ridge of the Pocono, which exposes a small area of the Catskill formation at the Lehigh River. The Mauch Chunk or Panther Creek syncline exposes the Pennsylvanian rocks, and the Lehighton anticline exposes the Hamilton formation. The Wire Ridge syncline exposes the Catskill formation to the northeast

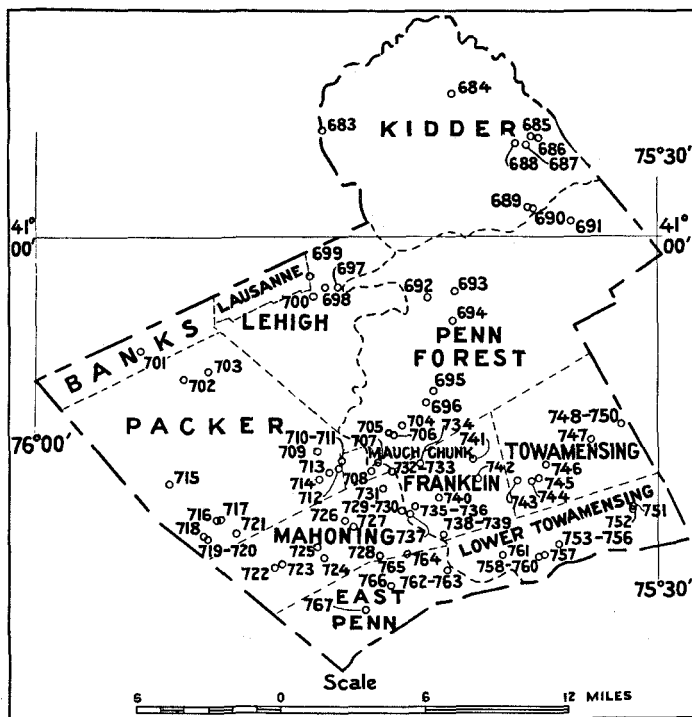


Figure 7. Map of Carbon County showing location of water wells

Mauch Chunk Township, omitted by error, occupies what is here shown as the southern part of Packer and Penn Forest Townships

and the Hamilton formation to the southwest. Between the Wire Ridge syncline and Kittatinny Mountain the structure is very complex, but the structure has been worked out by tracing the three separate outcrops of the Oriskany sandstone. The northernmost outcrop continues in a long straight line across the county, and the beds form the north limb of an anticline overturned to the north with an average dip of about 70° S. The anticline was not a simple fold but contained several minor anticlines and synclines, and one of these synclines with vertical walls was faulted down south of the anticlinal axis and now exhibits two secondary outcrops of the Oriskany and associated formations. The

⁸² See Winslow, Arthur, Map and sections along the Lehigh River: Pennsylvania Geol. Survey Ann. Rept. for 1886. pt. 4. sheet 8. 1887.

fault, which trends northeast, has been described by Chance⁸³, Hill⁸⁴, and Agthe and Dynan⁸⁵. A small syncline occurs just east of Germans, and the beds at Germans are cut by a north-south fault. Kittatinny Mountain is a steep monoclinal ridge with normal northwest dips increasing to the northwest.

WATER-BEARING FORMATIONS

[See pp. 41-67 for further description]

Glacial drift.—The presence of Wisconsin and Illinoian drift has been established in Carbon County, and there may be slight traces of Jerseyan drift in the southwestern part, but none of it was observed by the writer. North of the Wisconsin drift border, in Kidder Township, the thickness of the drift ranges from a few feet to more than 150 feet. On the north shore of Lake Harmony many wells penetrate 100 feet of clay, "quicksand," and gravel before reaching bedrock, and one well 150 feet deep obtains water from a bed of coarse boulders overlain by "quicksand" and gravel. On the south side of the lake the drift is only 15 to 25 feet thick. (See wells 685 to 688.)

The Lehigh River flows through a rock gorge in most places, and no excessive depths of outwash material were recorded in well records. Well 736, near the middle of the narrow river valley at Weissport, penetrated 30 feet of coarse sand and gravel.

Aquashicola Creek meanders over a buried valley until it reaches the town of Palmerton, where its course is obstructed by a moraine about 80 feet high which has forced the creek to erode a new channel through Cayuga shales, leaving a round hill of red shale isolated from the main mass of Kittatinny Mountain. This moraine is shown on pl. 1 as the lower limit of the Illinoian drift border. The Palmer Water Co. has four dug wells (753 to 756) of excellent construction in the drift-filled valley about half a mile northeast of Aquashicola. The wells range in depth from 12½ to 23½ feet and yield from 115 to 250 gallons a minute from beds of gravel and boulders. A test hole drilled here went down 50 feet without reaching bedrock, but one of the dug wells encountered bedrock at a depth of 12 to 15 feet. The temperature of the water from well 756 was 68° F. on September 23, 1930. This high temperature, together with the proximity of the wells to Aquashicola Creek, seems to indicate that the water percolates into the gravel beds from the creek near the wells or a short distance upstream. Doubtless many more strong wells of this type could be developed along the valley of Aquashicola Creek.

Post-Pottsville and Pottsville formations.—The post-Pottsville formations, including the Allegheny formation and probably a small part of the Conemaugh formation, crop out in the Panther Creek coal basin and in the Beaver Meadow coal basin. The beds in the Panther Creek coal basin have been severely folded and contorted, with numerous anticlines within the main syncline. The Pottsville contains workable coal beds but consists largely of coarse conglomerate and hard sandstone, with

⁸³ Chance, H. M., Special survey of the Lehigh Water Gap: Pennsylvania Geol. Survey, 2d ser., Rept. G-6, pp. 349-352, 1882.

⁸⁴ Hill, F. A., Report on the metallic paint ores along the Lehigh River: Pennsylvania Geol. Survey, Ann. Rept. for 1886, pt. 4, pp. 1386-1408, 1887.

⁸⁵ Agthe, F. T., and Dynan, J. L., Paint-ore deposits near Lehigh Gap, Pa.: U. S. Geol. Survey Bull. 430, pp. 442-445, 1910.

a 60-foot bed of red shale near its base. The hard Pottsville rocks form the Nesquehoning and Pisgah Mountains, which have preserved the Panther Creek coal basin from erosion, and crop out around the Beaver Meadow coal basin.

In the Panther Creek coal basin the Pottsville and post-Pottsville formations are not sources of potable ground water, because of coal-mining operations, but they contain considerable water, which must be pumped or drained out of the mines. The coal beds dip very steeply, and consequently considerable surface water drains into the open strip-ping pits and down into the underground workings. The eastern or "spoon" end of the syncline is drained by a tunnel between the Nesquehoning Colliery and Lehigh River, a distance of about 21,000 feet, at a maximum depth of 1,000 feet. With the kind permission of Mr. Hold, colliery superintendent, Mr. Sterner, colliery engineer, accompanied the writer through the drainage tunnel in August, 1930. It was observed that the rocks were dry between the depths of 600 and 1,000 feet and that most of the water came from the upper levels. At a depth of 1,000 feet the post-Pottsville, Pottsville, and Mauch Chunk formations penetrated by the tunnel were fractured, but most of the fractures were tightly closed, and only a few of them dripped water. In the summer of 1930 the flow was only about 1,500 gallons a minute, the lowest flow recorded. The maximum flow recorded took place after a very heavy rain and was estimated at 43,000 gallons a minute. The water is unfit for drinking and is reported to be slightly acid, but iron rails that had been on the tunnel floor for more than 15 years were still serviceable.

A shallow drilled well in Beaver Meadow obtains a small supply of water from post-Pottsville sandstone, but the owner reports that wells which were formerly in use close to the coal mines have been drained by mining operations. No well records were obtained for the Pottsville in this locality, because its outcrop areas are largely uninhabited.

Mauch Chunk shale.—The Mauch Chunk shale is well developed at Mauch Chunk, the type locality, and in long, narrow valleys on both sides of the Panther Creek coal basin. The sandstones and some of the shales of the Mauch Chunk yield small supplies of water to drilled wells about 60 to 100 feet deep and larger supplies to wells about 100 to 600 feet deep. The wells in Banks, Lausanne, and Lehigh Townships are all less than 100 feet deep and yield adequate domestic supplies. In Mauch Chunk, East Mauch Chunk and the valleys on both sides of the Panther Creek basin a number of wells have been drilled for municipal and industrial supply. These wells range in depth from 112 to 606 feet and are pumped at 70 to 375 gallons a minute. Most of the wells obtain water under artesian head from beds of sandstone. Some of the wells flow 20 to 35 gallons a minute, and one diamond-drill hole 200 feet deep was reported to have had a flow of about 150 gallons a minute before it was plugged. All the wells in the Mauch Chunk east of the Lehigh River were reported to be flowing wells, and the geologic structure appears to be ideal for artesian conditions. (See wells 704 to 706.) The wells of the Mauch Chunk Water Co. (712 to 714) near Mauch Chunk range in depth from 406 to 606 feet and yield 70 gallons a minute by pumping. The wells of the Summit Hill Water Co. (718 to 720) are 250 feet deep and yield 160 to 225 gallons a minute. The water from the

Mauch Chunk carries very little dissolved mineral matter, as shown by the analyses of water from wells 704, 712, and 718.

Pocono sandstone.—The outcrops of the Pocono in Carbon County form steep ridges or high mountains containing only a very sparse rural population, so that there are only a few shallow domestic wells equipped largely with small hand pumps. The water is reported to be of excellent quality.

Catskill group.—The Catskill group crops out over most of Kidder and Penn Forest Townships and on several ridges in the southern part of Carbon County.

The sandstones and shales of the Catskill yield water of a very good quality, but in general the hard, fractured sandstones yield more than the soft shales. All the wells recorded for the Catskill formation are domestic wells and, with two exceptions they range in depth from 37 to 114 feet and yield 8 to 20 gallons a minute. Two 150-foot wells south of Mauch Chunk yield 60 and 75 gallons a minute with small draw-downs. It is probable that considerably more water could be obtained by deeper wells.

Portage group.—The Portage group crops out along a narrow belt about a third of a mile wide that crosses Lehigh River above Lehighton, and forms a double outcrop around the Wire Ridge syncline, the two outcrops uniting at two places west of the Lehigh River. The strata dip very steeply to the north at the locality above Lehighton.

Wells in the Portage range in depth from 40 to 110 feet, are reported to yield 5 to 25 gallons a minute and are all used for domestic supply. The thin-bedded sandstones or flagstones are probably capable of yielding much larger supplies of water, but no data are available in Carbon County to verify this. Well 736, in Weissport, is only 100 feet deep and is reported to yield 60 gallons a minute continuously. However, the well is adjacent to Lehigh River, where bedrock is overlain by 30 feet of water-bearing sand and gravel, and most of the water may percolate down into the black shale from the river sand and gravel. The water from the Portage is reported to be of good quality, but may contain hydrogen sulphide.

Hamilton formation.—The Hamilton formation is partly exposed in the northeastern part of the Lehighton anticline and is completely exposed in a narrow belt southeast of the Wire Ridge syncline, which crosses Lehigh River above Bowmanstown.

Records were obtained on only four wells in the Hamilton, two of which are 72 and 127 feet deep and are reported to yield 10 and 5 gallons a minute each. Well 729 is 150 feet deep and flows 3 to 4 gallons a minute but would doubtless yield considerably more by pumping. The strongest well reported for the Hamilton is well 730, which is 305 feet deep and is reported to yield 150 gallons a minute continuously. Moderate supplies are obtainable from the shales or slates and large supplies similar to that of well 730 can probably be obtained from the sandstones. The water is reported to be of good quality.

Marcellus shale.—The Marcellus shale crops out in a narrow belt of varying width, which crosses Lehigh River at Bowmanstown. It consists entirely of black shale and slate, which has been mined for roofing

slate in some places. The beds have been severely crushed by folding and faulting so that it is very difficult to determine their exact thickness, but it has been estimated at 800 feet. The beds dip steeply to the north in most places but are locally vertical or overturned.

The shales and particularly the hard, brittle slates have been crushed and fractured, so that numerous openings have been provided for the movement of ground water. A few domestic wells were recorded in the Marcellus, all of which were less than 50 feet deep and were reported to yield 10 to 15 gallons a minute. The water from the Marcellus is reported to be of good quality.

Onondaga formation.—The Onondaga formation is composed of an upper bed of cherty limestone 5 feet thick, underlain by a hard, fine-grained hydraulic limestone of varying thickness which was formerly mined and manufactured into hydraulic cement⁸⁶. Beneath this limestone lies a bed of clay averaging about 6 inches in thickness, a bed of paint-ore averaging about 2 feet, and a bed of soft blue and yellow clay 2 to 8 feet thick overlying the Oriskany sandstone. The paint-ore beds are of sedimentary origin and extend in a northeast-southwest direction for about 20 miles. The ore resembles blue limestone when first mined but turns red on oxidation. It consists principally of iron carbonate containing about 35 percent of metallic iron. The ore has been mined and used for the manufacture of paint since 1856⁸⁷.

No wells are known along the outcrops of the Onondaga, but water has been encountered in the paint-ore mines. Considerable water enters the tunnel of the Prince Manufacturing Company's mine at Little Gap, at a point about 800 feet from the mouth. The water appears to contain considerable iron and is reported to form red boiler scale. The borough of Bowmanstown is supplied with water collected in an abandoned ore tunnel which ends at the paint-ore horizon, and the water is reported to contain considerable iron.

Oriskany sandstone.—The Oriskany sandstone crops out on a long, narrow, steep ridge and is quarried for sand at several places in Carbon County, the massive blocks of sandstone crushing readily into loose sand.

The coarse sandstone beds of the Oriskany appear to be very porous, but the beds are vertical or overturned and form a steep barren ridge, on which only one well is known. The Alliance Sand Co. at Palmerton has a drilled well (761), 109 feet deep, just below its quarry, which formerly yielded 15 to 20 gallons a minute, but it is reported that the yield has been reduced by mining activities near the foot of the hill.

Helderberg limestone.—The Helderberg limestone crops out beneath the Oriskany along the south side of the Oriskany ridges. The measured thickness of the Helderberg in this region is 207 feet, but of this the upper 152 feet consists of sandstone and cherty, sandy shale which may be Oriskany or Helderberg. The lower 55 feet, which has been definitely assigned to the Helderberg, consists of 17 feet of arenaceous, calcareous shale, 1 foot of sandstone and 37 feet of sandy, shaly, impure limestone resting on the Bossardville limestone.

Well data are not available for the Helderberg in Carbon County, and

⁸⁶ Hill, F. A., op. cit., p. 1389.

⁸⁷ For a complete history, description, and bibliography, see Agthe, F. T., and Dynan, J. L., op. cit., pp. 440-454.

the narrowness of its outcrop makes it unimportant as a source of ground water, but it is known to be water-bearing in Monroe County.

Cayuga group.—The Cayuga group crops out along the broad valleys of Aquashicola and Lizard Creeks north of Kittatinny Mountain. Only the lower and upper parts of the Cayuga are exposed along Lehigh River, for glacial drift covers about 2,000 feet of the middle part.

The only wells in the Cayuga on which data were obtained were the four drilled wells of the Palmer Water Co. (757 to 760), south of Palmerton. They range in depth from 300 to 304 feet and yield 115 to 130 gallons a minute. All the wells obtain water of good quality from the Bloomsburg red beds which apparently constitute a very good water-bearing formation.

Clinton formation and Tuscarora sandstone.—The Clinton formation and Tuscarora sandstone occupy the crest and most of the northern slope of Kittatinny Mountain, and the outcrop areas are steep, heavily wooded, and practically devoid of habitation. Because of their topographic position there are no wells along their outcrops, and nothing is known as to their water-bearing properties in Carbon County.

ARTESIAN CONDITIONS

Although the water level in most of the drilled wells in Carbon County stands considerably above the point at which water was first encountered, there is apparently only one locality where several flowing wells have been obtained. This is the valley marked by the outcrop of the Mauch Chunk formation around the Panther Creek syncline. There are two wells now flowing and a plugged well reported to have flowed years ago about a mile northeast of East Mauch Chunk. (See wells 704 to 706). In Mauch Chunk, Bloomingdale, and Hauto the wells do not flow, but the water level is very close to the surface. (See wells 710 to 721).

The only other flowing well reported in the county is well 729, in Leighton, which is drilled apparently on an anticline. The Wire Ridge syncline is not favorable for flowing wells, because the core of the syncline stands at a higher altitude than the rim rocks.

It is possible that flowing wells might be obtained along the north slope of Kittatinny Mountain, but no wells have been drilled high on the mountain.

QUALITY OF WATER

The analyses tabulated on page 78 indicate the chemical composition of three samples of water from drilled wells in the Mauch Chunk shale, one from a dug well in the glacial drift near Palmerton and one from a spring. These analyses represent waters that are noticeably low in dissolved mineral matter. The quality of the water obtained from the other water-bearing formations is reported to be good, but no analyses are available to check the reports.

PUBLIC SUPPLIES

The six public waterworks using ground water are listed in the subjoined table. Buck Mountain also utilizes spring water for public supply, but data were not available for tabulation. Only two of the four largest boroughs, Palmerton and Summit Hill, use ground water. The other two, Lansford and Leighton, are supplied with surface water.

Other places using surface water are Weissport, Weatherly, Rockport, Nesquehoning and Hauto.

Audenried, Tresekow and Kelayres are supplied by the Honeybrook Water Co., which also supplies McAdoo in Schuylkill County. The company has two large reservoirs impounding 156,000,000 gallons from two groups of springs, and two flowing wells used only for auxiliary supply.

DOMESTIC AND INDUSTRIAL SUPPLIES

Many dug wells are still in use in Carbon County, chiefly on farms, but there are also numerous drilled wells in the rural districts. Small springs are utilized for domestic supply in many places.

Most of the industrial establishments are located in the larger towns and use municipal water, but a few of them have drilled wells, including an ice company, a packing company, a silk mill, and a sand company. In the anthracite districts the coal mines are supplied largely with surface water from municipal water companies owned by the coal companies.

Analyses of waters in Carbon County

[Parts per million. Numbers less than 1200 correspond to numbers on map and in the tables of well data]

	704	712	718	756	1200 ¹
Silica (SiO ₂) -----	----	6.7	----	9.9	----
Iron (Fe) -----	----	.08	----	.01	----
Calcium (Ca) -----	(²)	5.2	3 ³	17	3 ³
Magnesium (Mg) -----	----	1.3	----	3.2	----
Sodium (Na) -----	} 1 ⁴	2.1	3 ⁴	4.9	1 ⁴
Potassium (K) -----	} .2	----	----	.6	----
Bicarbonate (HCO ₃) -----	8.0	21	14	51	10
Sulphate (SO ₄) -----	(²)	1.6	(²)	14	13 ³
Chloride (Cl) -----	1.0	1.5	2.0	1.2	1.0
Nitrate (NO ₃) -----	.0	.10	.62	.83	.10
Total dissolved solids -----	11 ⁴	29	19 ⁴	78	28 ⁴
Total hardness as CaCO ₃ -----	----	----	----	----	----
(calculated) -----	9.0 ⁵	18	10 ⁵	56	21 ⁵
Date of collection (1930) ---	Sept. 23	Sept. 23	Sept. 23	Sept. 23	Sept. 23

¹ Abandoned paint-ore tunnel in Bowmanstown, 1,000 feet long, Marcellus or Onondaga.

² Less than 2 parts. ³ By turbidity. ⁴ Calculated. ⁵ Determined.

Analysts: 704, 718, K. T. Williams, 712, 756, 1200, L. A. Shinn.

Public water supplies in Carbon County derived from ground water

Borough	Population 1930	Owner	Source	Geologic source	Storage (gallons)	Average daily consumption	Treatment	Remarks
Beaver Meadow	1,890	Citizens Water Co.	2 springs		1,800,000	30,00 \pm gallons	None	Part of town supplied by Wyoming Valley Water Co.
Bowmanstown	843	Maurice Bowman	Abandoned paint-ore tunnel	Marcellus Condaga	10,000 \pm	100 \pm consumers	do	See analysis 1200; water reported to contain considerable iron
East Mauch Chunk	3,739	Mauch Chunk Water Co.	Stream and 2 drilled wells	Wells in Mauch Chunk	1,635,000	600 consumers	Chlorine gas	See wells 704-706; analysis 704.
Mauch Chunk	3,206	do	Stream and 3 drilled wells	do	500,000 \pm	400 consumers	do	See wells 712-714; analysis 712.
Palmerton	7,678	Palmer Water Co.	4 dug wells and 5 drilled wells (auxiliary)	Dug wells in glacial drift; drilled wells in Bloomsburg	188,000	453,000 gallons	do	See description of dug wells on p. 73; see wells 753-760; analysis 756; some water used by manufacturers and railroad.
Summit Hill	5,567	Summit Hill Water Co.	1 spring and 3 drilled wells	Mauch Chunk	300,000	84,000 gallons	do	See wells 718-720; analysis 718.

Drilled wells in Carbon County

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No.	Location ¹	Owner or tenant	Topographic situation	Altitude ² (feet)	Depth (feet)	Diameter (inches)	Character of water-bearing material	Geologic horizon	Length of casing (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
	Kidder Twp.												
683	East Side ----	James Martini --	Hillside	1,160	78	6	Red sand-stone	Mauch Chunk	30	35	5	D	Bedrock overlain by 26 feet of drift boulders with very little sand and clay.
684	3½ miles south-west of Blakeslee ----	Oscar Dotter ----	Upland	1,820	63	-----	-----	Catskill	a	24	6	do.	Bedrock overlain by 100 feet of boulders, clay, "quicksand", and gravel.
685	North shore of Lake Harmony	George Freby --	Lakeside	1,860	133	-----	Red shale	do.	100	16	-----	do.	
686	do	F. Durur -----	do	1,880	150	6	Boulders	Glacial drift	150	60	-----	do.	Well does not reach bedrock. Coarse boulders overlain by "quicksand" and gravel.
687	South shore of Lake Harmony	B. Dunlop ----	do	1,860	47	6	Red shale	Catskill	16	25	15±	do.	Very little glacial drift on the south side of Lake Harmony.
688	do	Costenbader ----	do	1,860	100	6	do	do.	25	45	8	do.	
689	Albrightsville --	F. Berger -----	Hillside	1,640	80	-----	-----	do.	-----	-----	-----	do.	
690	0.6 mile east of Albrightsville	M. Owen -----	do	1,600	135	6	-----	do.	20	70	-----	do.	
	Penn Forest Twp.												
691	2.3 miles east of Albrightsville	R. Getz -----	Valley	1,594	58	6	Red sand-stone	do.	26	-----	15	do.	Dug well deepened by drilling.
692	½ mile west of Unionville	Henry Helmer --	Hilltop	1,580	81	6	-----	Pocono	-----	-----	-----	do.	Several drilled wells near Unionville range in depth from 80 to 100 feet.
693	0.9 mile east of Unionville	P. Green -----	Saddle	1,639	103	6	-----	Catskill	35+	15-30	-----	do.	Dug 35+ feet; deepened by drilling to 103 feet.
694	1.6 miles south-west of Christmans	N. Green -----	Hillside	1,570	66	6	-----	do.	-----	15-30±	-----	do.	Dug well deepened by drilling.

GROUND WATER

695	3 miles north-east of East Mauch Chunk	Mr. Hall	Hilltop	1,650	94	6	Sandstone	Pocono or Catskill	17½	50	4	do.	
696	2½ miles north-east of East Mauch Chunk Lehigh Twp.	Mr. Behrens	do	1,602	93	6	Red shale	do.	20	-----	-----	do.	Bedrock overlain by 20 feet of clay.
697	Rockport	Mr. Buchman	Valley	940	99	6	Hard red sandstone	Mauch Chunk	10	-----	-----	do.	
698	½ mile north-west of Rockport	Mr. Miller	Hillside	1,120	75	6	do	do.	17	30	5—	do.	Pumps dry at 5 gallons a minute.
699	1.4 miles north-west of Rockport	Mr. Kennedy	do	1,180	65	6	Hard blue sandstones some conglomerate	do.	28	30±	-----	do.	
700	1 mile west of Rockport Banks Twp.	Mr. Sours	do	1,150	60	6	Red sandstone	do.	25	36	5	do.	Drawdown 9 feet pumping 5 gallons a minute for 10 minutes; soil 5 feet, red shale 20 feet (cased), red sandstone (water-bearing) 35 feet. Water level reaches the surface during wet seasons; bedrock overlain by 2 to 3 feet of soil; owner reports that mining operations have not affected this well but that several wells lower down and closer to the mines have been drained.
701	Beaver Meadow Packer Twp.	N. Yackanicz	do	1,450	27	-----	Sandstone	Post-Pottsville	-----	0-13	-----	do.	
702	1 mile west of Hudsondale	Mr. Paseoe	do	1,200	70	-----	-----	Mauch Chunk	-----	30±	-----	do.	Dug 33 feet to the bedrock; drilled 37 feet into bedrock.
703	Hudsondale Mauch Chunk Township	Mr. Rhonig	Valley	1,080	79	6	Red shale	do.	13½	35-40	-----	do.	
704	1½ miles north-east of East Mauch Chunk	Mauch Chunk Water Co.	Canyon	960	408	8	-----	do	20	Flows	70	P S	Flows 20 gallons a minute; pumps 70 gallons a minute; see analysis; coal (?) struck at a depth of 200 feet. Temperature 56° F. Sept. 23, 1930.

Drilled wells in Carbon County—Continued

No.	Location ¹	Owner or tenant	Topographic situation	Altitude ² (feet)	Depth (feet)	Diameter (inches)	Character of water-bearing material	Geologic horizon	Length of casing (feet)	Depth to water level (feet)	Yield (gallons) a minute	Use of water ³	Remarks
705	$\frac{3}{4}$ mile north-east of East Mauch Chunk	Mauch Chunk Water Co.	Canyon	800	300	10	Sandstone	Mauch Chunk	20	Flows	250	P S	Flows 36 gallons a minute; draw-down 38 feet pumping 250 gallons a minute for 3 weeks; coal (?) struck at a depth of 250± feet.
706	$\frac{3}{4}$ mile north-east of East Mauch Chunk	do	do	800	200	1 $\frac{1}{2}$	-----	do.	-----	-----	-----	N	Diamond-drill prospect hole for coal; it is reported that formerly the water shot up 20 feet into the air and the well flowed about 150 gallons a minute; the hole has since been plugged.
707	$\frac{1}{2}$ mile south-east of Mauch Chunk	Mauch Chunk Power & Light Co.	Valley	500±	150	10-8-6	Sandstone and conglomerate	Catskill	50	30	60	D	Small draw-down pumping 60 gallons a minute; gravel and boulders 40 feet, red shale and sandstone, green sandstone and conglomerate, red shale; surface water in gravel is highly acid from the river.
708	Flagstaff -----	Electric R.R. --	Hilltop	1,308	150	6	Red and blue sandstone Red shale	do.	Shallow	50	75	do.	Small draw-down pumping 75 gallons a minute; dug 50 feet; drilled to 150 feet.
709	2 miles east of Nesquehoning	Cemetery -----	Hillside	700±	62	6		Mauch Chunk	32	30	10	do	Draw-down 30 feet pumping 140 gallons a minute for 10 hours.
710	$\frac{1}{2}$ mile west of Mauch Chunk	Ice Co. -----	do	950±	150	-----	Red sandstone	do.	84	50±	140	Ind	Draw-down 30 feet pumping 140 gallons a minute for 10 hours; 300 feet from well 710.
711	$\frac{1}{2}$ mile west of Mauch Chunk	do	do	950±	112	6	do	do.	17	50±	140	do.	Draw-down 100 feet pumping 70 gallons a minute; see analysis; soil (cased) 86 feet, conglomerate or hard sandstone 400 feet, red sandstone and shale (water-bearing) 170 feet. Temperature 50° F. Sept. 22, 1930.
712	$\frac{3}{4}$ mile west of Mauch Chunk	Mauch Chunk Water Co.	do	800±	606	8	do	do.	36	46	70	P S	

713	1 mile west of Mauch Chunk	do	Valley	850±	406	8	do	do.	24	-----	40 ?	do.	Flows from a point below the surface through a trench; reported yield 40 gallons a minute in 1927.
714	1½ miles west of Mauch Chunk	do	do	940±	406	8	do	do.	24	24	30 ?	do.	Flows from a point 24 feet below the surface through a trench; reported flow 30 gallons a minute in 1927.
715	0.4 mile west of Hauto	Panther Valley Water Co.	do	1,000	600	10	do	do.	-----	12	375	do.	Draw-down 50± feet pumping 375 gallons a minute for 24 hours a day by air lift.
716	Bloomingtondale	W. Embody	Edge of valley	1,100	75	-----	-----	do.	-----	-----	-----	D	
717	do	Mr. Gorman	do	1,100	96	6	Red shale	do.	84	40	15	do.	Yellow clay (cased) 84 feet, red shale (water-bearing) 12 feet.
718	1 mile south-east of Summit Hill	Summit Hill Water Co.	Valley	1,100	250±	10-8	Hard blue sandstone	do.	40	27 ?	225	P S	It is reported that prior to 1928 this well flowed during wet seasons; depth to water in 1928 was 27 feet, has not been measured since; yields 225 gallons a minute by air lift 5 hours a day; see analysis; soil 15 feet, red shale 25 feet, hard blue sandstone from 40 feet to (?); water is chlorinated. Temperature 53° F. Sept. 23, 1930.
719	do	do	do	1,100	250	10-8	do	do.	40	9.6?	160±	do.	It is reported that the depth to water was 9 feet 7½ inches in 1918, not measured since; draw-down 59 feet 2½ inches pumping 161 gallons a minute for 24 hours.
720	do	do	do	1,100	250	15-8	do	do.	40	5.6?	225	do.	It is reported that this well flowed in 1928; depth to water in 1918 was 5 feet 8 inches; draw-down 53 feet 4 inches pumping 227 gallons a minute for 24 hours.
721	¾ mile south-east of Bloomingtondale	J. Habaty	High saddle	1,280	54	6	-----	Pocono	16	20±	5	D	Draw-down 15 feet pumping 5 gallons a minute for 5 minutes.
	Mahoning Twp.												
722	New Mahoning	Mr. Beltz	Edge of valley	600	40	6	Black shale	Portage	23	20-25	10	do.	
723	0.4 mile north-east of New Mahoning	Mr. Frantz	do	600	63	6	do	do.	28	20	-----	do.	

Drilled wells in Carbon County—Continued

No.	Location ¹	Owner or tenant	Topographic situation	Altitude ² (feet)	Depth (feet)	Diameter (inches)	Character of water-bearing material	Geologic horizon	Length of casing (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
724	$\frac{1}{2}$ mile south-east of Pleasant Corners	Mahoning Country Club	Valley	500	88	6	Black shale	Portage	19 $\frac{1}{2}$	25 \pm	25	D	Dug 50 feet; drilled to a depth of 82 feet.
725	Pleasant Corners	Ollie Bittner	Hillside	580	82	6	do	do.	-----	50	10	do.	
726	$\frac{1}{2}$ miles north-east of Pleasant Corners	D. McHugh	do	660	80	6	Black "slate"	do.	25	25 \pm	-----	do.	
727	$\frac{1}{2}$ miles south-west of Lehigh-ton	Mr. Billman	do	560	83	6	Blue "slate"	do.	37	40	8	do.	Moderate draw-down pumping 8 gallons a minute.
728	Dry Tavern	Mr. Rheinheimer	do	820	98	6	Hard blue sandstone	do.	28	50	8	do.	Draw-down 20 feet pumping 8 gallons a minute; surface—soft yellow shaly rock 28 feet, slate 30 feet, hard blue sandstone 40 feet.
729	Lehigh-ton	E. Phifer	do	540	150	-----	-----	Hamilton	-----	Flows	3-4	do.	Well began flowing at a depth of 100 feet, flows 3 to 4 gallons a minute but should yield considerably more by pumping.
730	do	J. Obert Packing Co.	do	520	305	8	-----	do.	-----	100 \pm	150	Ind	Well has been pumped at 150 gallons a minute continuously for 3 weeks; air lift pipes extend to a depth of 260 feet.
731	$\frac{1}{2}$ mile north-west of Jamestown	H. J. Danzer	Canyon	620	76 $\frac{1}{2}$	6	-----	Catskill	60	-----	-----	D	Well was originally 45 feet deep with adequate water supply; deepening to 104 feet did not change the yield.
732	Packerton	Fred Armbuster	Hillside	650	104	-----	-----	do.	-----	-----	-----	do.	
733	do	Mr. Snyder	do	680	114	6	Soft red shale	do.	16	74	8	do.	

	Franklin Twp.												
734	Waleksville ----	Long Run School	Valley	640	55	6	Red shale	do.	25	20	20	do.	Small draw-down pumping 20 gallons a minute.
735	North Weissport	Franklin School	Low Hill	560	110	6	Blue "slate"	Portage	25	30	6	do.	
736	Weissport -----	Hufford Silk Mill	Valley	460	100	6	Black "slate"	do.	30	8	60	Ind		Moderate draw-down pumping 60 gallons a minute all day; on shore of Lehigh River; bed-rock is overlain by 30 feet of sand and coarse gravel; water contains some hydrogen sulphide.
737	do	E. Arner -----	Hillside	520	127	6	Hard blue sandstone	Hamilton (?)	14	60	5	D	Large draw-down pumping 5 gallons a minute. Pumps dry at 10 gallons a minute.
738	Parryville ----	H. J. Lynn	do	447	92	6	Yellow shale	Portage	16	50	10—	do.	
739	do	Harry Brown	do	447	93	6	Hard gray-green sandstone	do.	6	50	8	do.	
740	East Weissport ½ mile south-east of Waleksville	Alonzo Mantz	do	520	75	-----	Blue slate	do.	21½	25±	8	do.	
741		Fish Hatchery	Valley	640	50	6	Hard blue sandstone	do.	0	10	-----	do.	
742	0.4 mile north-east of Big Creek	Mr. Strohl	Hillside	560	72	6	Black slate	Hamilton	41	40±	10	do.	
	Towamensing Township												
743	½ mile north-west of Stemlersville	James S. Dunbar	Valley	880	60	-----	Gray-green sandstone	Catskill	-----	5-18	-----	do.	Dug well; large quartz crystals encountered in digging.
744	¼ mile north-east of Stemlersville	P. O. Frantz	Valley	820	45	-----	Red shale	do.	3	8	-----	do.	
745	0.6 mile north-east of Stemlersville	M. Stemler	do	940	60	-----	-----	do.	-----	-----	-----	do.	Adequate supply; a 40 foot well nearby goes dry during the summer.
746	Forest Inn ----	Forest Inn	Ridge	1,006	90	-----	-----	Catskill or Portage	-----	-----	-----	do.	
747	1.4 miles west of Trauchsville	P. Kellow	Hilltop	960	118	-----	-----	Portage	-----	14	-----	do.	Dug 30 feet; drilled to 99 feet.
748	Trauchsville	Robert Bier	Ridge	947	58	-----	-----	do.	-----	-----	-----	do.	
749	do	do	do	947	99	-----	-----	do.	-----	-----	-----	do.	
750	do	Jerusalem Church	do	947	104	6	Sandstone	do.	31	60	-----	do.	

Drilled wells in Carbon County—Continued

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No.	Location ¹	Owner or tenant	Topographic situation	Altitude ² (feet)	Depth (feet)	Diameter (inches)	Character of water-bearing material	Geologic horizon	Length of casing (feet)	Depth to water level (feet)	Yield (gallons) a minute	Use of water ³	Remarks
751	Lower Towamensing Twp. Little Gap	Wallace Costenbader	Valley	462	36	6	Black "slate"	Marcellus	16	6±	10	D	Well 1 of four dug wells spaced 200 to 300 feet apart in gravel-filled valley near Aquashicola Creek; one test hole went down 50 feet without reaching bedrock, yet one of the wells struck bedrock; wells are all walled with stone, provided with sanitary covers and ventilators, and connected to a central pumping sump by means of large siphons (See p. 73.)
752	do	John Roth	do	462	?	6	do	do.	35	15-20		do.	
753	$\frac{1}{2}$ mile north-east of Aquashicola	Palmer Water Co.	do	4 406.5	12.5	120±	Coarse gravel and boulders	Glacial outwash	-----	6.5	115	P S	
754	$\frac{1}{2}$ mile north-east of Aquashicola	do	do	4 406.0	12.5	do	do	do.	-----	6	150	do.	Well 2.
755	$\frac{1}{2}$ mile north-east of Aquashicola	do	do	4 406.9	22.93	do	do	do.	-----	6.9	130	do.	Well 3.
756	$\frac{1}{2}$ mile north-east of Aquashicola	do	do	4 406.9	23.4	do	do	do.	-----	6.9	250	do.	Well 4; see analysis; Temperature 68° F. Sept. 23, 1930.
757	$\frac{1}{4}$ mile south of Aquashicola	do	Hillside	4 442	304	10	Red shale	Cayuga	102	54	115	do.	Well 8; draw-down 80 feet pumping 115 gallons a minute for 2 hours; yield measured by meter; bedrock overlain by 100 feet of gravel and sand.
758	$\frac{1}{4}$ mile south of Aquashicola	do	do	4 397	302	8-6	do	do.	85	11	130	do.	Well 7; small draw-down pumping 130 gallons a minute continuously; yield measured by meter.

759	$\frac{3}{4}$ mile south of Aquashicola	do	do	⁴ 422.5	301	8-6	do	do.	97	34	120	do.	Well 6; small draw-down pumping 120 gallons a minute continuously; yield measured by meter.
760	$\frac{1}{2}$ mile south of Aquashicola	do	do	⁴ 490.0	300	8	do	do.	30	54	130	do.	Well 5; draw-down 90 feet pumping 130 gallons a minute for 10 hours.
761	$\frac{1}{4}$ mile north of Pahnerton	Alliance Sand Co.	do	740	109	6	Sandstone?	Oriskany ()	47	-----	15-20	Ind	Depth to water when drilled 40 feet; it is reported that in 1929 the water level dropped nearly to the bottom, presumably owing to mining operations near the foot of the hill.
East Penn Twp.													
762	Bowmans -----	A. A. Bowman	do	420	47	-----	Black shale	Marcellus	17	15	15	D	
763	Bowmans -----	H. P. Bowman	do	460	50	-----	do	do.	-----	-----	-----	do	
764	$\frac{1}{2}$ miles north-west Bowmans	Mr. Rherig	do	780	40	6	Hard blue sandstone	Portage	23	20	-----	do.	
765	1.1 miles north of Ashfield	Mr. Zehner	do	860	37	6	do	do.	13	20	8	do.	
766	0.2 mile north of Ashfield	Mr. Andreas	do	600	80	6	-----	do.	33 to 38	33+	-----	do.	Draw-down 10 feet pumping 8 gallons a minute.
767	$\frac{1}{2}$ miles south-west of Ashfield	Mr. Frantz	Edge of valley	544	45	6	Black slate	Marcellus	36	25	10	do.	Dug 33 feet; drilled to 80 feet.

¹ No distance indicates well is in town.² Generally estimated from nearest contour line or bench mark on topographic map.³ D—Domestic; Ind—Industrial; N—None; PS—Public supply.⁴ Altitudes from instrumental survey by Palmer Water Co.

COLUMBIA COUNTY

GENERAL FEATURES

Area 479 square miles; population 48,803

Columbia County lies in the west-central part of the area described in this report. Berwick, the largest borough, has a population of 12,660; Bloomsburg has 9,093 and Centralia 2,446. Industrial development is centered along the Susquehanna Valley and the Western Middle anthracite field, in the southernmost part of the county. In 1929 there were 82 manufacturing establishments with annual products valued at \$5,000 or more, and in 1930 there were 9 coal mines. A large part of the county is occupied by small farms, of which, in 1930, there were 2,279.

The highest point in Columbia County is on North Mountain at the northeast corner of the county where the altitude is 2,450 feet. Catawissa Mountain attains an altitude of 1,941 feet at the easternmost corner of Roaring Creek Township and there are numerous sharp-crested ridges in the county ranging from 1,600 to 1,800 feet. Susquehanna River leaves the county at Roaring Creek with an altitude of 460 feet, which is the lowest point in the county.

With the exception of the northwest corner of Madison Township, which is drained by the West Branch of Susquehanna River, and the south half of Conyngham Township, which is drained by Shamokin Creek into the main Susquehanna, all of Columbia County is drained by the North Branch of Susquehanna River, which flows southwestward through the center of the county with an average gradient of about 1.14 feet to the mile.

GEOLOGY AND GROUND WATER

GENERAL SECTION

Only a small part of Columbia County was covered by the last advance of the ice, but traces of one and possibly two older stages of glaciation have been observed over the remainder of the county. (See drift borders on pl. 1.) The Wisconsin drift border crosses Susquehanna River near Beach Haven, enters Columbia County on the north slope of Huntington Mountain, and follows a northwesterly course through Fishing Creek, Benton, and Jackson Townships. Extensive drift deposits, which extend through the county along Susquehanna River and in the northern part of the county, have been regarded as of Illinoian age, and still older isolated patches of what may be Jerseyan drift have been observed. The only pre-Wisconsin glacial material which is important as a source of ground water is that found along Susquehanna River.

The rock formations exposed in Columbia County range in age from the post-Pottsville Pennsylvanian formations down to the Clinton formation. The youngest rocks, the Pennsylvanian and Mississippian, are exposed along the southern, eastern, and northern borders of the county, and the oldest rocks, the Silurian and Lower Devonian, are exposed only along Montour Ridge through the center of the county. Rocks of Middle and Upper Devonian age crop out over the greater part of the county.

Generalized section for Columbia County

Geologic unit	Maximum thickness exposed (feet)	Character of rocks	Ground-water conditions
Glacial drift (Wisconsin, Illinois, Jerseyan ?)	140	Wisconsin and Illinois drift; sand, clay, and gravel on higher ground north of drift borders. Small patches of Jerseyan (?) drift; thick deposits of Wisconsin outwash along Susquehanna River and Fishing Creek.	Wisconsin outwash sand and gravel most important surficial deposit; yields small to very large supplies of good water to dug and drilled wells. Some failures due to quicksand.
Post-Pottsville Pennsylvanian formations	1,200±	Sandstone, shale, slate, fire-clay; 12 to 15 workable coal beds.	Unimportant; no wells reported. Head lowered and water polluted by coal mining.
Pottsville formation	850±	Coarse conglomerate, gray and greenish sandstone and shale; a few workable beds of coal.	Unimportant; no wells reported; crops out only on high mountains.
Mauch Chunk shale	2,000±	Largely red shale, with beds of red and green sandstone and green shale.	Supplies a few shallow domestic wells in Catawissa and Beaver Valley and two strong wells in Roaring Creek Valley. Water reported to be of good quality.
Pocono sandstone	600±	Coarse gray and yellowish sandstone and shale and massive grayish-white conglomerate.	Unimportant; no wells reported; crops out only on high mountains.
Catskill group	1,700±	Red shale, red and gray cross-bedded sandstone, green and white sandstone; gray sandstone and shale in lower part.	Yields small supplies to shallow domestic wells, and moderately large supplies to wells 200 to 375 feet deep. Water is of good quality.
Portage group	2,400±	Alternating beds of gray and olive-green shale and hard whitish or greenish-gray sandstone, black shale and limestone at base.	Yields small supplies of good water to shallow domestic wells.
Hamilton formation	1,000±	Brown, gray, and bluish-gray sandy shale and sandstone.	Wells 50 to 250 feet deep generally yield adequate domestic supplies; one deep well yields large industrial supply.
Marcellus shale	410±	Black and dark-blue fissile slate and shale, gray near base.	Water generally of good quality but may contain hydrogen sulphide.
Oriskany sandstone	40±	Cherty rotten yellow sandy beds; absent or concealed east of Bloomsburg.	Not known; no wells known to penetrate it; absent in most places.
Helderberg limestone	235±	Largely blue pure and impure limestone, with some interbedded shale and hard sandstone.	Yields large supplies of medium-hard water to several industrial wells; iron-bearing water from one well.
Cayuga group	1,430±	Tonoloway limestone, 105± feet; Wills Creek shale (buff and pale-green limestone and sandy shale), 329 feet; Bloomsburg red beds, (red and green shale and sandstone), 840± feet; calcareous shale and olive-green sandstone (McKenzie and Clinton), 150± feet.	Tonoloway yields large supplies of medium-hard water to several industrial wells. Bloomsburg supplies several wells with 10 to 20 gallons a minute of very soft water. Very few data on remainder of formation.
Clinton formation	1560-710±	Fossil iron ore, hard ferriferous red sandstone, and yellowish green and olive-green shale.	Unimportant in Columbia County; forms crest of high ridge.

¹ Not entirely exposed.

STRUCTURE

In Columbia County the rocks have been folded into seven alternating synclines and anticlines, which trend east or northeast. The folds inter-finger with one another, the anticlines plunging to the east and the synclines rising to the west, so that progressively older beds are exposed on the anticlines toward the west and progressively younger beds are exposed on the synclines toward the east. The folds from north to south are (1) a syncline exposing the Pocono sandstone on North Mountain; (2) the Milton anticline, exposing the Middle Devonian rocks between

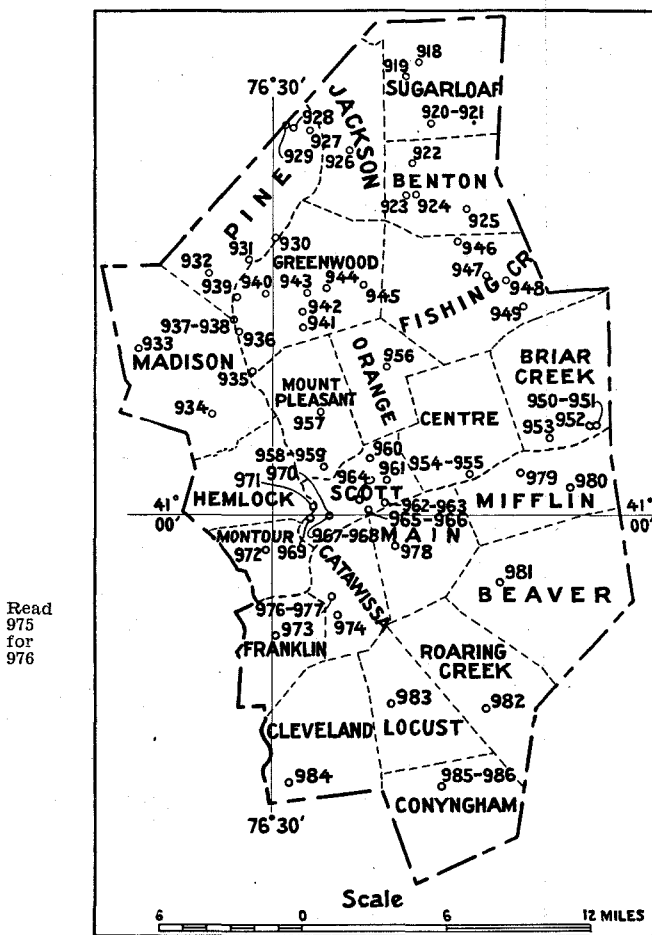


Figure 8. Map of Columbia County showing location of water wells

Millville and Fishing Creek; (3) the Lackawanna syncline, which rises rapidly to the west and exposes the Mauch Chunk between Huntington and Lees Mountains; (4) the Berwick (Montour) anticline, which exposes the Clinton formation along Montour Ridge; (5) the Northumberland syncline, which becomes a synclinorium to the east and exposes several small patches of the post-Pottsville formations belonging to the Eastern Middle anthracite field; (6) the Selingsgrove anticline, which

exposes the Portage group in Columbia County east of Elysburg; and (7) the large Shamokin syncline, which exposes the post-Pottsville formations of the Western Middle anthracite field.

The Berwick (Montour) anticline is the only ridge-forming anticline in the county: the other anticlines form valleys or areas of low relief. In the synclines the Pocono sandstone and the Pottsville formation form high even-crested ridges, and the other rocks form valleys and areas of low relief.

WATER-BEARING FORMATIONS

[See pp. 41-67 for further description.]

Glacial drift.—Glacial drift of Wisconsin, Illinoian, and Jerseyan (?) age has been mapped in Columbia County. The Jerseyan (?) is present only in a few patches south of Knob Mountain and in Greenwood and Jackson Townships and is relatively unimportant as a source of ground water, except that it probably supplies a few dug wells. The Wisconsin drift supplies a few dug wells in the northeastern part of the county, but the stratified outwash sand and gravel derived from it is of much more importance. This outwash, presumably Wisconsin, is found chiefly in the valleys of Huntington and Fishing Creeks and along Susquehanna River. Along the Susquehanna the valley fill is apparently composed of Wisconsin outwash material forming terraces and small patches of Illinoian drift, and the Illinoian drift border has been traced downstream as far as Selinsgrove. Hummocky topography is still exhibited among the low mounds of clay, sand, and gravel 1 mile northwest of Rupert, and an examination of the pebbles showed that they were more deeply weathered than typical Wisconsin pebbles and are probably Illinoian. It is apparent that in preglacial time Susquehanna River flowed through the abandoned valley between Bloomsburg and Danville along which run the State highway and the Catawissa division of the Reading Railway. The river was presumably damned by Illinoian drift near Rupert and forced to cut the present gorge through the hard sandstones of the Portage-Catskill formations. Depths of valley fill of as much as 121 feet at Bloomsburg and 116 feet at Riverside indicate the possibility of deep scouring at these two places by the Illinoian ice lobe. The maximum reported depth to bedrock along the abandoned valley is only 40 feet, and in the absence of more well records along this valley it appears that the bedrock channel is considerably higher than it is at Riverside or Bloomsburg.

Along Fishing Creek the glacial outwash supplies numerous dug wells and a few drilled wells with water of very good quality. Well 924, in Benton, is 44½ feet deep in gravel and yields 140 gallons a minute with small draw-down. The Benton Water Co. has a dug well (923) only 10 feet deep near West Creek, which yields 830 gallons a minute with a drawn-down of only 1½ feet. The sand and gravel along the creek are not everywhere water-bearing, however, for dry holes have been drilled at Coles Creek and at Jonestown on Huntington Creek. (See wells 921 and 949.) The failure at Jonestown was due to "quicksand." As Little Fishing Creek lies southwest of the Wisconsin drift border, its valley is not filled with outwash, and bedrock is exposed along most of its course. At Millville, however, where the Illinoian drift border has been traced, a deposit of drift 20 to 30 feet deep supplies the two dug wells of the Millville Water Co. (well 937), which normally yield 60 gallons a minute.

Along Susquehanna River the glacial drift is of variable thickness, and in some places it contains beds of water-bearing sand and gravel, but most of the drilled wells along the valley obtain water from the underlying bedrock. Well 952 in Berwick is 140 feet deep and obtains a large supply of water from beds of sand on top of limestone. Other wells in Berwick obtain water from the underlying limestone but penetrate 40 to 80 feet of drift. The depths of glacial drift in other wells along the Susquehanna are reported as follows: Well 953, $2\frac{1}{4}$ miles west of Berwick, 35 feet; wells 954 and 955, in Lime Ridge, $55\pm$ and $40\pm$ feet; wells 962 and 963, in Espy, 80 and 30 to 40 feet; wells 965-970 in Bloomsburg, 36 to 121 feet. Bloomsburg is underlain to depths ranging from 36 to at least 121 feet by sand or "quicksand" and gravel, and it is reported that the gravel beds contain considerable water, although all the wells enter bedrock. The "molding sand" reported in the log of well 968 is also obtained from the surface of the ground 1 mile northwest of Rupert and is used as molding sand. At the Rupert locality it is only about 5 feet thick beneath a thin soil mantle and is composed of a fine buff clayey silt that will stand in a vertical wall 5 feet high without caving.

It is possible that with improved methods of well construction and with the use of well screens or strainers, considerable water could be obtained from beds of water-bearing gravel and perhaps even from the coarser beds of sand found along Susquehanna River and along Fishing Creek. (See pp. 33-35.)

Post-Pottsville formations.—The post-Pottsville formations (of Pennsylvanian age) occupy a very small area in Columbia County. They crop out at the summit of Bucks Mountain, in Beaver Township, and over most of Conyngham Township, in the Western Middle coal field, where they contain 12 to 15 workable coal beds. Owing to the lowering of artesian head and pollution of water by coal mining, no successful wells are known to exist in the post-Pottsville beds of Columbia County.

Pottsville formation.—The Pottsville formation crops out over a very small area on Bucks Mountain adjacent to the Western Middle coal field in Conyngham Township. Three of the Lykens Valley coal beds are present in the Pottsville, but they reach their maximum development farther west.

The Pottsville is a very good water-bearing formation farther to the east and southeast, but it is unimportant in Columbia County. Its outcrops form heavily wooded ridges devoid of habitations, and no wells were reported anywhere along them.

Mauch Chunk shale.—The Mauch Chunk shale crops out over most of Beaver Township and small parts of Main, Roaring Creek, Locust, and Conyngham Townships.

In Catawissa and Beaver Valleys the Mauch Chunk supplies a few shallow domestic wells, of which well 981 is more or less typical. No deep wells were reported in this region, but it is probable that large supplies could be obtained from properly constructed deep wells.

In Roaring Creek Valley between Little and Big Mountains the Roaring Creek Water Co. has two strong wells in the Mauch Chunk (wells 985-986). The wells are 299 and 302 feet deep and are reported to yield 300 gallons a minute each, with moderate draw-down. The water is re-

ported to be of good quality, and the static water level stands close to the ground surface.

Pocono sandstone.—The Pocono sandstone crops out on North, Nescopeck, Huntington, Catawissa, Knob and Little Mountains. The hard sandstone dipping 40° - 45° toward the coal basins, forms a high rocky ridge devoid of habitations and apparently without any drilled wells. The Pocono is known to be a very good water-bearing formation farther east, however.

Catskill continental group.—The Catskill continental group crops out in three large areas in the northern, central and southern parts of the county. Although a large part of the Catskill consists of red shale, many of the wells encounter one or more beds of red or gray sandstone containing fractures, which transmit water more freely than the more compact shales. Domestic wells in the Catskill range in depth from 35 to 125 feet and yield from 1 to more than 10 gallons a minute. Most of these wells are equipped with hand pumps, however, so that the maximum yield is not known. The only deep wells reported in the Catskill are those of the Catawissa Water Co. (wells 975-977). Two of these wells are 275 and 375 feet deep and yield 70 gallons a minute each, with small draw-down. A third well 205 feet deep located nearby is not being used, and on September 4, 1931, a recovery test was run by measuring the depth to water level in the unused well, shutting off the pumped wells, and taking repeated measurements of the depth to water level in the unused well for 76 minutes. The results of this test are described on page 35 and are shown in figure 6.

Well owners report that the water obtained from the Catskill is of good quality.

Portage group.—The Portage group crops out in four large areas in Columbia County, exposed by the Milton, Berwick (Montour), and Selinsgrove anticlines.

The wells observed in the Portage are all domestic wells ranging in depth from 53 to 156 feet. Yields as low as one-third gallon a minute were reported, but most of the wells yield adequate domestic supplies. The water is generally of good quality, especially from beds of sandstone, but in some places the water from the dark shales contains some hydrogen sulphide.

Hamilton formation and Marcellus shale.—The Hamilton formation and Marcellus shale are exposed by the Milton anticline in the northern part of the county and crop out in two narrow strips around the Berwick (Montour) anticline.

The Marcellus consists of dark shale and slate. The slate is well fractured and yields more water than the shale. The Hamilton contains sandy shale and sandstone, which yield adequate supplies of water, but generally the yields obtained from the two formations do not differ greatly. The quality of water in both formations is also similar in that many of the wells yield hydrogen sulphide. In the vicinity of Iola the deeper wells are reported to yield H_2S but the shallow wells, yielding less water, do not. The opposite was reported in a well near Greenwood, in which the water containing H_2S occurred only in the upper 50 feet of slate. The limestone at the top of the Hamilton was not reported in any of the wells for which records were obtained.

The reported depths of domestic wells in these formations ranges from 50 to 254 feet and the wells are reported to yield 3 to 25 gallons a minute. Well 933 flows a few gallons a minute. The deepest well reported is that of the Horbison Dairy, in Millville (well 936), which is 512 feet deep and yields a large supply of water of satisfactory quality. (See analysis 936).

Onondaga formation and Oriskany sandstone.—The Onondaga formation is doubtfully represented at a few localities by a few feet of hard sandy shale with some impure limestone around the Berwick (Montour) anticline. The Oriskany sandstone is absent or concealed by the debris east of Bloomsburg and is represented to the west by cherty, rotten, yellow sandy beds which are very thin in most places but are about 40 feet thick near the Montour County line.

No wells are known to penetrate any of these formations so that their water-bearing properties are unknown to the writer. Their probable absence east of Bloomsburg and thin outcrops to the west make them unimportant as sources of ground water in Columbia County.

Helderberg limestone.—The Helderberg limestone crops out in narrow strips on both sides of the Berwick (Montour) anticline. The chief quarry limestone is not the Helderberg, but the underlying Tonoloway limestone, and in some places it is difficult to determine whether wells end in the Helderberg or the Tonoloway.

In general water in limestone occurs chiefly in solution channels, but the Helderberg contains some thin beds of limestone in which bedding planes and fractures, enlarged by solution in some places, allow free movement of ground water. Only three wells are recorded with certainty in the Helderberg, but some of the wells in Bloomsburg and Berwick recorded in the table of drilled wells to end in the Cayuga (?) may be drawing water, at least in part, from the Helderberg. The three wells believed to end in the Helderberg are all industrial wells ranging in depth from 128 to 380 feet and yielding 16, 125, and 250 gallons a minute, with small draw-down. However, although all the wells ending in limestone in Columbia County were reported to be successful, the possibility exists of encountering massive limestone relatively free from fractures or solution channels, with the result that the yield may be small.

A large spring owned by the Berwick Water Co. wells up from the bed of Susquehanna River at the foot of the cliff below Berwick, presumably from the Helderberg limestone, for the water is reported to have a hardness of 150 parts per million. This spring, with a reported yield of about 1,250,000 gallons a day, formerly supplied the borough of Berwick, but it is now used only about 3 months a year to supplement the surface water supply. An analysis of water from well 970 shows a hardness of 164 parts per million, which is not excessive for limestone water. The sample, however, contained 6.6 parts per million of iron (Fe), which is enough to render the water unsuitable for making ice. The source of this iron is probably the underlying ferriferous beds of the Cayuga group, which crop out higher on the flank of the anticline.

Cayuga group.—The Cayuga group crops out around the Berwick (Montour) anticline and forms the entire ridge between Light Street and Berwick. The Cayuga includes, from top to bottom, the Tonoloway limestone, Wills Creek shale, Bloomsburg red beds, and possibly the McKenzie formation.

The Tonoloway limestone has water-bearing properties very similar to the Helderberg limestone described above and is believed to supply wells 950, 951, and 969, at Berwick and Bloomsburg, although, as stated previously, some doubt exists as to whether some of the wells end in Helderberg or Tonoloway. The three wells are all industrial wells 90 to 212 feet deep. One well 202 feet deep is reported to yield 185 gallons a minute, and the others are reported to have large yields. The quality of water is probably very similar to that from the Helderberg. (See analysis 970.)

Very little is known about the water-bearing properties of the thin-bedded buff and green limestone, sandy shale, and alternating red and green shale and limestone (Wills Creek) underlying the Tonoloway limestone in Columbia County, but they are known to yield large supplies of very hard water in Northumberland County along the Milton anticline:

The Bloomsburg red beds are very similar in lithology to the red shales in Mauch Chunk formation and also yield water that is very low in dissolved mineral matter. (See analysis 960.) They supply five domestic and industrial wells ranging in depth from 69½ to 145 feet with 10 to 20 gallons a minute of soft water. Very little is known about the water-bearing properties of the olive-green shale and sandstone (McKenzie?) forming the lower 150 feet of the Cayuga group as here tentatively delimited. They crop out well up on Montour Ridge and are relatively unimportant. Where the Cayuga is cut into by Fishing Creek, most of the wells (dug) obtain water from glacial drift.

Clinton formation.—The Clinton formation forms the crest of Montour Ridge west of the village of Light Street, and to its hard sandstones is due the preservation of the ridge. Only a part of the Clinton is exposed in Columbia County where Fishing Creek has cut through the ridge. The Clinton fossil iron ore was formerly mined at numerous places along Montour Ridge.

The Clinton is relatively unimportant as a source of ground water in Columbia County, for it crops out only along the crest of the ridge.

ARTESIAN CONDITIONS

Only two flowing wells (933, 940) were reported in Columbia County, both of which are on the flanks of the Milton anticline and flow but a few gallons a minute. The rocks generally appear to have been highly fractured by folding, so that in most places water-table conditions prevail. In some of the wells the water level doubtless stands somewhat above the point at which water was first encountered, but except for the two wells mentioned above the water level generally lies below the ground surface.

The Catawissa Water Co. has three drilled wells in the Catskill formation (wells 975-977) of which two are pumped at 70 gallons a minute each and the other one is not being used. On Septemebr 4, 1931, after wells 976 and 977 had been pumping 6 hours and 10 minutes, the depth to water level in well 975 was measured, the two pumps were stopped, and measurements of the depth to water level in well 975 were made every 2 minutes for 76 minutes. The measurements were plotted as a recovery curve and are shown in figure 6 together with the location of the wells. When the pumps were running the depth to water level in

well 975 was 20.60 feet, and after the pumps had been idle for 76 minutes it was 13.61 feet, showing a rise of 6.99 feet. As shown in figure 6, the water was still rising at the time measurements were stopped, indicating that it had not yet reached a static level. The recovery curve resembles that of a water-table well more closely than that of a true artesian well, for the recovery is gradual, whereas under true artesian conditions the recovery is very rapid at first, then tapers off gradually. (See also p. 35.) The water is reported to come chiefly from beds of red and gray sandstone near the bottom, and it is possible that the water in these beds is under some artesian pressure but that the intervening beds of red shale are not absolutely impermeable and allow the water to escape to higher levels, so that pumping drains the upper rocks just as it does under typical water-table conditions.

QUALITY OF WATER

The analyses tabulated at the end of the next page, indicate and compare the chemical composition of four samples of water from drilled wells in four different hard-rock formations and one sample from a well in glacial drift. The drift sample contained only 18 parts per million of total dissolved solids and 6 parts per million of hardness. This water is much softer than that from any of the hard-rock formations. The sample from the Helderberg limestone was collected from a drilled well owned by an ice company and has a sediment which contained 6.6 parts per million of iron (Fe). The water is used only for cooling, as it cannot be used satisfactorily for making ice, because the iron forms a red precipitate at the center of the ice cakes. This was the only occurrence of excess iron reported, and it is thought that the iron comes from the ferriferous Cayuga beds, which crop out higher on Montour Ridge.

In general the ground waters of Columbia County are satisfactory for most purposes, but it will probably be more economical to employ softeners on waters from the Helderberg or Tonoloway limestones in case the water is to be used for boiler feed. Waters from the dark shales of the Genesee, Hamilton, and Marcellus are likely to contain some hydrogen sulphide, but this is present only in small amounts and is therefore harmless.

PUBLIC SUPPLIES

The four public water supplies using ground water in Columbia County are listed in the subjoined table. Catawissa is supplied largely with surface water, but the other three are supplied entirely with ground water. Berwick, the largest borough in the county, is supplied with surface water, but this supply is supplemented during the summer by a large spring described on another page. Bloomsburg and Centralia are supplied with surface water. Aristes is connected to the Wyoming Valley Water Co.'s line and supplied with surface water. The villages, such as Light Street, are supplied by individually owned wells and springs.

DOMESTIC AND INDUSTRIAL SUPPLIES

The chief use of ground water in Columbia County is for domestic purposes. Villages, such as Light Street, Mordansville, Numidia, and Jerseytown, are supplied almost entirely by dug wells, some of which were reported to be dry during the summer of 1930. Throughout the county there are many more dug wells than drilled wells, but the num-

ber of drilled wells is increasing and eventually will probably exceed the number of dug wells.

The creameries appear to be the chief industrial users of potable ground water, for there are four creameries using drilled wells. The coal collieries in Conyngham Township probably use the largest amount of ground water, but it is derived as mine drainage and used only for washing coal. Other industries using ground water include a brick company, a heating company, and an ice and cold storage company. Most of the industries aside from coal collieries are located in the larger towns and use municipal water.

Public water supplies in Columbia County using ground water

Borough	Population—1930	Owner	Source	Geologic source
Benton	733	Benton Water Supply Co.	1 dug well and 3 small springs	Glacial drift
Catawissa	2,023	Catawissa Water Co.	Stream and 2 drilled wells (auxiliary)	Catskill
Millville	666	Millville Water Co.	2 dug wells	Glacial drift
Orangeville	415	Knob Mountain Spring Water Co.	5 springs	Glacial drift or Catskill

Borough	Storage (gallons)	Average daily consumption	Treatment	Remarks
Benton	50,000	167 consumers	None	23 fire plugs supplied.
Catawissa	250,000	50,000 gallons	None	Wells 975-977: see analysis, 977; consumption, 80 percent by inhabitants, 20 percent by manufacturers.
Millville	175,000	150 consumers	Chlorine gas	Well 937; also supplies a silk mill.
Orangeville	100,000	83 consumers	None	12 fire plugs supplied.

Analyses of waters in Columbia County

[Parts per million. Numbers correspond to numbers on map and in the tables of well data]

	924	936	960	970	977
Silica (SiO ₂)	---	---	---	---	12
Iron (Fe)	---	---	---	6.6	.08
Calcium (Ca)	2 ¹	11 ¹	9 ¹	48 ¹	26
Magnesium (Mg)	---	---	---	---	6.3
Sodium (Na)	4 ²	79 ²	4 ²	32 ²	3.8
Potassium (K)	---	---	---	---	1.9
Bicarbonate (HCO ₃)	10	199	44	219	25
Sulphate (SO ₄)	5 ¹	2 ¹	1 ¹	32 ¹	61
Chloride (Cl)	1.0	55	2.0	14	2.8
Nitrate (NO ₃)	.83	.0	4.6	2.2	13
Total dissolved solids	18 ²	257 ²	48 ²	253 ²	146
Total hardness as CaCO ₃	6.0	72	34	164	91 ²
Date of collection	Oct. 30, 1930	Oct. 30, 1930	Sept. 30, 1930	Sept. 4, 1931	Sept. 4, 1931

¹ By turbidity. ² Calculated.

Analysts: 924, 936, 960, L. A. Shinn; 970, 977, M. D. Foster.

Drilled wells in Columbia County

No.	Location ¹	Owner or tenant	Topographic situation	Altitude ² (feet)	Depth (feet)	Diameter (inches)	Character of water-bearing material	Geologic horizon	Length of casing (feet)	Depth to water level (feet)	Yield (gallons) a minute	Use of water ³	Remarks
918	Sugarloaf Twp. 1½ miles south of Central	T. Connor	Valley	-----	35	-----	-----	Catskill	-----	15±	Small	D	Goese dry in summer.
919	west of Lan-backs	Calvin Kyle	-----	-----	90	6	Red shale	do.	30	30	2-3	do.	Bedrock overlain by 30 feet of sand and gravel.
920	Coles Creek	Club House	Valley	800	80½	6	-----	do.	20½	30±	-----	do.	Dug 20½ feet; drilled to 80½ feet.
921	do	Parsonage	do.	820	62½	6	-----	Glacial drift	62½	-----	0	N	Dry hole; drilled 62½ feet into sand and gravel.
922	Benton Twp. ½ mile west of Coles Mills	Gene Fritz	Canyon	800	30	6	-----	do.	30	10	20	D	Water encountered near bottom; well does not reach bedrock.
923	½ mile west of Benton	Benton Water Supply Co.	Valley	780	10	48	Gravel	do.	10	5±	830	P S	Dug well 3 feet above and 30 feet away from stream; flows a large amount in wet weather; draw-down 1½ feet pumping 830 gallons a minute for 3 hours.
924	Benton	Glendale Milk Co.	do.	780	44½	6	do.	do.	44½	10±	140	Ind	Small draw-down pumping 140 gallons a minute; water-bearing gravel overlain by "hard-pan"; see analysis 924.
925	2¼ miles southeast of Benton	Dayton Hess	Canyon	880	100	6	Blue sand-stone	Portage	17	30	-----	D	
926	Jackson Twp. 1½ miles southwest of Waller	Jesse Young	-----	1,440	80±	6	Red shale	Catskill	20	60±	5	do.	
927	Pine Twp. 2½ miles west of Waller	Warren Johnson	Hill	1,350	125	6	Gray "slate" and sand-stone	do.	4	40	1	do.	Water reported to be hard.

928	1½ miles east of Unityville	Ernest Baker	do.	1,400	63	6	Red shale	do.	25	20	7	do.	Small draw-down pumping 7 gal- lons a minute for 10 minutes.
929	1½ miles east of Unityville	do.	Valley	1,240	113	6	do.	do.	27	60	Small	do.	Dug 27 feet; drilled to 113 feet.
930	1½ miles north- east of Sereno	H. Bitler	do.	-----	80	6	Black "slate"	Portage	12-15	-----	-----	do.	Strong odor of hydrogen sul- phide.
931	¾ mile north of Sereno	W. Greenly	Hillside	-----	90	6	do.	do.	12-15	25±	-----	do.	Do.
932	2 miles north- west of Mill- ville	D. Wetherel	-----	-----	88	-----	Hard gray sandstone	do.	-----	30±	2	do.	Dug 33 feet; drilled to 88 feet; principal water-bearing bed at 80 feet; pumps dry pumping 2 gallons a minute.
Madison Twp													
933	2 miles north- west of Jersey- town	Mr. McGargle	-----	-----	250	-----	Dark "rock"	Hamilton	20	Flows	2	do.	Flows 2 gallons a minute; water level more than 9 feet above the surface of the ground.
934	2½ miles south- east of Jersey- town	Roy Derr	Hilltop	-----	78	6	Gray shale	Portage	48	10-15	-----	do.	Bedrock overlain by 48 feet of sand, gravel and clay.
Greenwood Twp.													
935	Eyers Grove	J. D. Matt	Valley	-----	84	6	Hard blue sandstone	do.	30	-----	-----	do.	
936	Millville	Horbison Dairy	do.	-----	512	5½	Black shale	Portage or Hamilton	20	20±	large	Ind	Large draw-down reported; water reported to be somewhat hard; see analysis 936.
937	do	Millville Water Co.	do.	-----	12	-----	Gravel and sand	Glacial drift	-----	7	60	P S	Two dug wells, one 10 feet in diameter, one rectangular 10 by 36 feet; in winter small draw- down pumping 60 gallons a minute; in October 1930 pumped dry in 2 hours pumping 60 gallons a minute.
938	do	F. Bartlow J. Bitler	do.	-----	69	6	Gray slate	Portage	10	4-5	3	D	Deeper drilling in and near Iola yields more water, but the water in deep wells contgins considerable hydrogen sulphide.
939	¾ mile south of Iola		do.	-----	30	6	do.	do.	14-15	12±	Small	do.	
940	1 mile north of Millville	Jacob Derr	-----	-----	110	6	Dark "slate"	do.	12-15	Flows	-----	do.	Flows a small quantity 10 months a year; water level drops below the surface 2 months a year; large yield by pumping.
941	1½ miles south of Greenwood	W. E. Ett	Hillside	720	150	-----	Gray slate	Portage or Hamilton	65	20±	15	do.	Water in upper 50 feet of slate cased off on account of hydro- gen sulphide; lower water satisfactory.

Drilled wells in Columbia County—Continued

No.	Location ¹	Owner or tenant	Topographic situation	Altitude ² (feet)	Depth (feet)	Diameter (inches)	Character of water-bearing material	Geologic horizon	Length of casing (feet)	Depth to water level (feet)	Yield (gallons) a minute	Use of water ³	Remarks
942	$\frac{3}{4}$ mile south of Greenwood	S. W. Eves	Hillside	700	135	6	Black "slate"	Portage	12	10-12	5-6	D	Draw-down 30 feet pumping 5 to 6 gallons a minute for 15 minutes.
943	Greenwood	Vernon Bangs	Canyon	860	90	6	Gray "slate"	do.	25±	20±	3	do.	Small draw-down pumping 3 gallons a minute; dug 25 feet; drilled to 80 feet.
944	$\frac{3}{4}$ mile east of Greenwood	J. E. Miller	Hillside	820	160	6	-----	do.	20±	14±	12-15	do.	
945	$\frac{1}{2}$ mile north-west of Rohrsburg	John Johnson	do.	720	50	5½	Black "slate"	do.	5-12	3	25	do.	Small draw-down pumping 25 gallons a minute.
	Fishing Creek Twp.												
946	$1\frac{1}{2}$ miles north-east of Stillwater	W. C. Davis	Hilltop	1,160	156	6	Gray sandstone	Portage	36	36±	-----	do.	Normal depth to water level 36 feet; water very low during October 1930, temperature 50° F.
947	1 mile east of Bendertown	Amos Winners	Hillside	1,000	114	6	Hard gray sandstone	do.	40+	-----	$\frac{1}{2}$	do.	Bedrock overlain by more than 40 feet of drift.
948	$\frac{1}{2}$ mile south of Bendertown	E. Winners	Ridge	960	53	6	Hard blue sandstone	do.	23	23±	-----	do.	Bedrock overlain by 23 feet of drift.
949	$\frac{1}{2}$ mile south of Jonestown	Harry Aple	Hillside	760	67	6	-----	Glacial drift	67	-----	-----	N	Dry hole drilled in sand and gravel, abandoned on account of quicksand.
	Briar Creek Twp.												
950	Berwick	Berwick Creamery	River terrace	560	212	6	Limestone	Cayuga (?)	40±	40±	large	Ind	Small draw-down; bedrock overlain by 40 feet of boulders, cobbles, and pebbles.
951	Berwick	E. Hines	do.	560	90±	-----	do.	do. (?)	80	14±	do.	D	Bedrock overlain by 80 feet of sand, gravel, and clay.
952	Berwick	Berwick Lumber and Supply Co.	do.	560	140	6	Sand	Glacial drift	140	20	do.	do.	Well drilled just to top of bedrock (flinty limestone).

953	2½ miles west of Berwick	Mr. Hopper	do.	540	60-70	-----	Gray shale	Cayuga	35	15-18	5-6	do.	Bedrock overlain by 30 feet of gravel, which contains some water.
	Center Twp.												
954	Lime Ridge	Dan Krum	River terrace	500	100	6	Black slate	Marcellus	55±	18-20	-----	do.	Bedrock overlain by 55 feet of gravel.
955	Lime Ridge	Charles Jamison	do.	500	90	6	do.	do.	40±	40±	3±	do.	Bedrock overlain by 40 feet of sand and gravel; water reported to be hard.
	Orange Twp.												
956	Orangeville	Dr. Port Gimel	Valley	550	80	6	Red shale	Catskill	60	6	-----	do.	Bedrock overlain by 60 feet of sand and gravel.
	Mount Pleasant Twp.												
957	Canby	Harry Melick	Hilltop	960	90	6	Red sand- stone and shale	do.	12-14	25	2	do.	
958	2½ miles north of Bloomsburg	T. N. Oman	Hillside	660	69½	6	Red shale	Cayuga	15±	12-15	10-12	do.	
959	1½ miles north of Bloomsburg	Bloomsburg Poor District	do.	560	125	6	do.	Bloomsburg	15	55	large	do.	
	Scott Twp.												
960	Light Street	Dairymen's Co- operative Association	do.	560	145	8-6	Hard red shale	do.	90±	30±	20	Ind	Draw-down 8 inches pumping 20 gallons a minute all day; bedrock overlain by 90 feet of gravel, clay, and "quicksand"; a former well was lost, owing to quicksand entering casing just above the bedrock; see analysis 960.
961	1 mile north- west of Al- media	Harry Sharpus	do.	680	100	6	Red shale	do.	60	-----	-----	D	
962	Espy	Mrs. Bilheim	River terrace	500	100	6	Gray "rock"	Hamilton	80±	25-30	Small	do.	Bedrock overlain by about 80 feet of gravel; gravel contains an abundance of water; well flowed before casing was set into bedrock, when the water level dropped to 25 to 30 feet below the surface.
963	Espy	H. W. Angle	do.	500	94	6	do.	do.	30-40	-----	-----	do.	Bedrock overlain by 30-40 feet of gravel; water contains hydrogen sulphide.

Drilled wells in Columbia County—Continued

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GROUND WATER

No.	Location ¹	Owner or tenant	Topographic situation	Altitude ² (feet)	Depth (feet)	Diameter (inches)	Character of water-bearing material	Geologic horizon	Length of casing (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
964	$\frac{1}{4}$ miles north-east of Bloomsburg	Bloomsburg Brick Co.	Hillside	580	101	6	Red shale	Bloomsburg	88	20	14+	Ind	Upper 83 feet of soft shale cased off.
965	$\frac{1}{2}$ miles east of Bloomsburg	Walter Hogg	River terrace	500	101	6	Gray "slate"	Portage or Hamilton	60	7	14	D	Small draw-down pumping 14 gallons a minute for a long period; bedrock overlain by 60 feet of gravel.
966	$\frac{1}{2}$ miles east of Bloomsburg	Fred Kohler	do.	500	85	6	Black "slate"	do.	86	20	21	do.	
967	Bloomsburg Town	Bloomsburg Heating Co.	do.	500	380	6	Limestone	Helderberg	-----	14±	125	Ind	Small draw-down pumping 125 gallons a minute.
968	Bloomsburg	Snyder Dairy	do.	500	128	6	do.	do.	121	30±	16	do.	Small draw-down pumping 16 gallons a minute; "molding sand" 92± feet, gravel 5± feet, quicksand 8 feet, rest is blue "rock"; considerable water in gravel, small quantity of water in the "molding sand."
969	Bloomsburg	Harry McGee	do.	500	202	8	Thin-bedded limestone	Cayuga (?)	48	42	185	do.	Draw-down 33 feet pumping 185 gallons a minute for 1 day; water reported to be very hard; bedrock overlain by 48 feet of sand and gravel.
970	Bloomsburg	Bloomsburg Ice & Cold Storage Co.	do.	-----	360	6	Limestone	Helderberg	-----	12	230	C	Contains too much iron (Fe) for use in ice making; see analysis 970.
971	Hemlock Twp. $\frac{1}{2}$ mile north-west of Bloomsburg	Fred Waters	do.	490	18.8	24	-----	Glacial drift	18.8	13.99	-----	N	Dug well; depth to water level measured Nov. 6, 1931, see pl. 4.
972	$\frac{1}{2}$ miles west of Rupert	Bruce Hartman	Valley	580	67	6	Brown shale	Marcellus	40	18-19	5-6	D	Bedrock overlain by 40 feet of "hardpan".

973	Franklin Twp. 2½ miles south- west of Cata- wissa Catawissa Twp.	E. Austin	Hillside	900	90	6	Gray shale	Catskill (?)	22	25-30	2	do.	
974	Catawissa	-----	Canyon	700	80-90	6	Hard yellow and white sandstone	Catskill	18	-----	1	do.	Exceptionally hard rock; drilling rate 8 inches a day; drilled just above a stone quarry.
975	½ mile south- east of Cata- wissa	Catawissa Water Co.	Hillside	540	205	10	Red and gray sandstone	do.	14	13±	-----	P S	Abandoned; see recovery test on pp. 95-96.
976	½ mile south- east of Cata- wissa	do.	do.	540	275	6	do.	do.	14	13±	70	do.	Small draw-down pumping 70 gallons a minute day and night.
977	½ mile south- east of Cata- wissa Main Twp.	do.	-----	-----	375	6	do.	do.	-----	13±	70	do.	Small draw-down pumping 70 gallons a minute day and night, see analysis 977.
978	1½ miles north- west of Main- ville Mifflin Twp.	Mr. Alstedder	Hilltop	860	90	6	-----	do.	12	50	10	D	
979	½ mile southwest of Mifflinville	P. O. of A. Orphanage	Hillside	620	254	6	-----	Portage (?)	23	50	15	do.	Yield doubled by discharging 120 pounds of dynamite at the bottom.
980	Hetlerville Beaver Twp.	G. Stevenson	do.	900	90	6	Red shale	Catskill	10	50	10+	do.	Red shale 80 feet, hard white rock 2 feet, red shale (water- bearing) 8 feet.
981	1 mile north- west of Beaver Valley Roaring Creek Twp.	Mr. Witmer	do.	1,000	60	6	Red sand- stone and shale	Mauch Chunk	10	20±	10+	do.	
982	1½ mile east of Mills Grove	Earl Huffman	do.	1,100	72	6	Yellow sand- stone and red shale	Catskill	18	18-20	3	do.	Pumps dry pumping 3 to 4 gal- lons a minute; large spring near well.

Drilled wells in Columbia County—Continued

No.	Location ¹	Owner or tenant	Topographic situation	Altitude ² (feet)	Depth (feet)	Diameter (inches)	Character of water-bearing material	Geologic horizon	Length of casing (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
983	Locust Twp. Numidia	W. Lavelle	Hillside	940	93	6	-----	Portage	40	30	Small	D	
984	Cleaveland Twp. 1 mile north-east of Bear Gap	W. Persing	do.	960	70	6	Hard red sandstone	Catskill	3-4	20±	2±	do.	
985	Conyngham Twp. 1½ miles north-west of Aristes	Roaring Creek Water Co.	Valley	1,160	299	8	-----	Mauch Chunk	-----	Shallow	300	P S	Moderate draw-down pumping
986	do. 1½ miles north-west of Aristes	do.	do.	1,160	302	10	-----	do.	-----	do.	300	do.	300 gallons a minute. Do

¹ No distance indicates well is in town.² Generally estimated from nearest contour line or bench mark on topographic map.³ C—Cooling; D—Domestic; Ind.—Industrial; N—None; PS—Public supply.

DAUPHIN AND LEBANON COUNTIES

GENERAL FEATURES

The area described under this heading lies in the southwest corner of the area described in this report and includes only those parts in Dauphin and Lebanon Counties which lie north of the crest of Kittatinny or Blue Mountain, the first mountain north of Harrisburg. Ground-water conditions in the parts of the two counties lying south of Kittatinny (Blue) Mountain have been described by Hall⁸⁸.

Dauphin County has an area of 522 square miles, about 321 square miles of which is covered by this report. Dauphin County had a population of 165,231 in 1930, but considerably more than half of the total live south of Kittatinny Mountain. There are no large towns north of Kittatinny Mountain, and only four towns have more than 1,000 inhabitants—Lykens with 3,033, Williamstown with 2,958, Millersburg with 2,909, and Elizabethville with 1,341. Lykens and Williamstown are in the Wiconisco coal basin, in which there were 11 anthracite mines in 1930. Aside from coal mining the greatest industrial development in the county is in Harrisburg, the State capital and largest city, which lies south of the area described in this chapter. In the area described the northern part and the southwestern part along Susquehanna River are largely devoted to farming, but the southern mountainous part adjoining Schuylkill and Lebanon Counties is practically a wilderness with very little cultivation and only a few scattered inhabitants.

Lebanon County has an area of 360 square miles, but the part lying within the area covered by the report covers only about 50 square miles and consists entirely of high ridges and narrow valleys. It is largely uninhabited except for a few dwellings at Indiantown and Swatara Gaps and a few scattered farms along Trout Run Valley. The Schuylkill and Susquehanna branch of the Reading Railway passes through Stony Creek Valley, in which there are three small stations—Rausch Gap, Cold Spring, and Yellow Springs. Large springs are located at Cold Spring and at St. Joseph Springs; the latter is reported to flow about 50 gallons a minute under normal conditions.

SURFACE FEATURES

Northern Dauphin and Lebanon Counties are traversed from southwest to northeast by a series of high, narrow, even-crested ridges—from south to north, Kittatinny (Blue, First, North) Mountain, Second Mountain, Third Mountain, bifurcating toward the northeast into Sharp Mountain and Stony Mountain, Peters Mountain and Berry Mountain, Big Lick and Coal Mountains, uniting to form Short Mountain, and Mahantango Mountain, at the northern border of Dauphin County. The summit of Big Lick Mountain rises to an altitude of 1,740 feet in Williams Township and is the highest point in Dauphin County. The lowest point in the part of Dauphin County covered by this report is in the bed of the Susquehanna at Rockville, at an altitude of about 310 feet. The maximum relief is therefore about 1,430 feet, and the local relief between ridges and valleys is commonly 600 to 1,000 feet. The highest point in Lebanon County is on Stony Mountain, which has an altitude of 1,600 feet at several places in Cold Spring Township. The lowest point in Lebanon

⁸⁸ Hall, G. M., Ground water in southeastern Pennsylvania: Pennsylvania Geol. Survey Bull. W2, pp. 156-160, 196-199, 1934.

County north of Kittatinny Mountain is the floor of Swatara Gap, which is about 420 feet above sea level, giving a maximum relief of about 1,380 feet.

The portions of Dauphin and Lebanon Counties covered by this report are drained entirely by Susquehanna River. In the northern part the drainage is carried to the Susquehanna by several small streams flowing toward the southwest, parallel to the strike of the rock strata. Part of the water falling in the first valley north of Kittatinny Mountain reaches the Susquehanna through the tributaries of Swatara Creek flowing through Heckert, Manada, Indiantown, and Swatara Gaps. In flowing from the Northumberland County line to the water gap at Rockville, a distance of about 28 miles, the Susquehanna drops about 80 feet, a gradient of about 2.88 feet to the mile.

GEOLOGY AND GROUND WATER

GENERAL SECTION

Dauphin and Lebanon Counties were not glaciated, and a study of the ground-water conditions concerns only the Paleozoic rock formations exposed on and north of Kittatinny Mountain. In Dauphin County these formations range in age from the post-Pottsville, of Pennsylvanian age, down to the Juniata, of Upper Ordovician age. The Juniata formation apparently terminates a short distance east of Rockville, so that the oldest formation in the part of Lebanon County treated in this report is the overlying Tuscarora sandstone, of early Silurian age. The post-Pottsville formations are also exposed in northern Lebanon County, where they are of very little commercial importance. The Second Geological Survey of Pennsylvania did not publish county reports for Dauphin and Lebanon Counties, and accurate stratigraphic data are lacking for many of the pre-Pennsylvanian formations.

Several Lower Devonian and late Silurian formations are lacking in Dauphin County and are probably lacking in most of Lebanon County, including most of the Marcellus, all of the Onondaga, Oriskany, and Helderberg, and a large part of the Cayuga group. (See p. 57.)

*Generalized section for Dauphin and Lebanon Counties north of
Kittatinny (Blue) Mountain*

Geologic unit	Maximum thickness exposed (feet)	Character of rocks	Ground-water conditions
Post-Pottsville formations	400-500	Sandstone, shales, slates, 5 or 6 workable coal beds.	Unimportant as source of ground water, owing to small areal extent, coal mining, and topographic position.
Pottsville formation	1,400±	Largely coarse quartz conglomerate, with some gray and green sandstone and shale and 7 workable coal beds.	
Mauch Chunk shale	3,000±	Largely red shale, with beds of red and green sandstone and green shale.	Most important water-bearing formation in northern Dauphin County; yields adequate supplies to shallow domestic wells, large supplies to deep wells. Some weak wells in places where rocks are tight.
Pocono sandstone	1,600±	Coarse gray and yellowish sandstone and massive grayish-white conglomerate; some red shale; 4-foot bed of coal on Peters Mountain.	Relatively unimportant, owing to topographic position; yields small supplies to shallow wells; one flowing well on summit of Berry Mountain yields moderately large supply of very soft water. In some places water contains an excess of iron.
Catskill group	4,500±	Red shale, red and gray cross-bedded sandstone, green and white sandstone.	Second most important water-bearing formation in northern Dauphin County. Yields adequate supplies to shallow wells, large supplies to deep wells. Water very soft.
Chemung formation and Portage group	1,750±	Dark shale, black shale, and thin-bedded sandstone.	Unimportant. Crop out over very small area on which there are very few drilled wells. Only one well observed.
Hamilton formation	1,100	Dark-gray shale and hard massive sandstone.	
Marcellus shale	0-100	Black slate.	
Onondaga formation, Oriskany sandstone, Helderberg limestone, and upper part of Cayuga group		Absent except in easternmost Lebanon County.	Unimportant.
Lower part of Cayuga group (Bloomsburg red beds) and Clinton formation	¹ 1,750± ² 2,650±	Hard red, green, and white sandstones, red and olive-green shales.	Unimportant. Yields small supplies to a few drilled wells at Susquehanna Gap.
Tuscarora sandstone	¹ 277- ² 300	Coarse quartz conglomerate, white and gray vitreous sandstones.	Unimportant; no wells observed.
Juniata formation	³ 70±	Red sandstone and hard white conglomerate.	

¹ Dauphin County. ² Lebanon County. ³ Not present east of Dauphin County.

STRUCTURE

The northern part of Dauphin County is a large syncline with rims of Pocono sandstone forming Mahantango and Berry Mountains. Toward the east the Pottsville and post-Pottsville beds are preserved in the Wiconisco coal basin. All the beds except the Mauch Chunk seem to be folded into a relatively simple syncline, but numerous minor folds occur in the Mauch Chunk. South of this syncline are two anticlines, one of which exposes the Hamilton and Marcellus north of Halifax. South of this is another large syncline, in the center of which lies the Dauphin-Schuylkill coal basin. The axial plane of this syncline appears to dip toward the south, and the Pocono sandstone forming the southern rim is overturned toward the south. From Second Mountain to Kittatinny (First) Mountain all the strata were overturned to the south by the intense folding that affected this region.

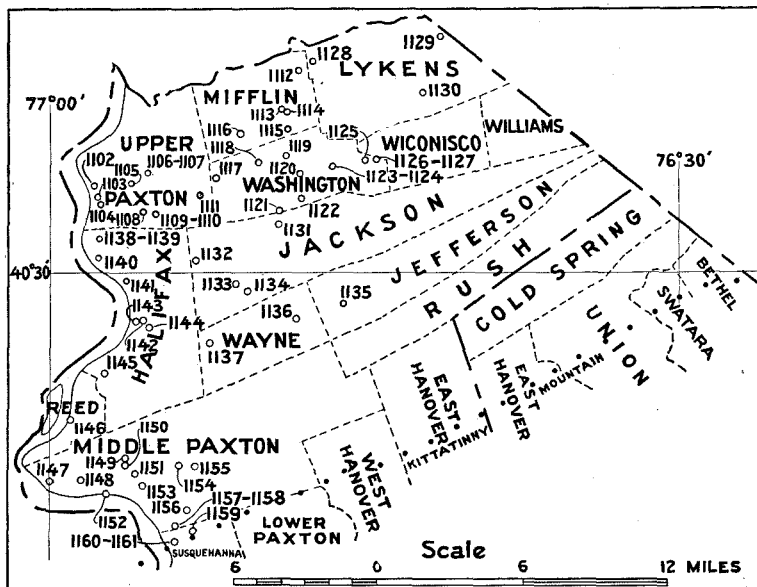


Figure 9. Map of northern Dauphin County showing location of water wells

WATER-BEARING FORMATIONS
[See pp. 46-48 for further description].

Post-Pottsville formations.—The post-Pottsville formations are exposed in Dauphin County in the Wiconisco coal basin between Big Lick and Coal Mountains. They are also exposed in the Dauphin-Schuylkill basin of Dauphin and Lebanon Counties at the summit of Third Mountain. The two coal basins form what is sometimes called the “fishtail” of the Southern coal field. The post-Pottsville beds contain five or six workable coal beds in this region, but they are unimportant as sources of potable ground water.

Pottsville formation.—The Pottsville formation crops out on a steep ridge around the two coal basins described in the last paragraph and forms Third Mountain and Short Mountain at the west end of the basins. In the Wiconisco basin it includes in its lower part seven workable beds

of coal, six of which are known as the Lykens Valley beds. Coal beds are also preserved in the Dauphin-Schuylkill basin, on Third Mountain, but are of less commercial importance because they have been severely squeezed and crushed by the intense folding that formed the syncline. The Pottsville is not important as a source of ground water in Dauphin and Lebanon Counties because of its small areal extent and topographic position.

Mauch Chunk shale.—The Mauch Chunk formation crops out in two large synclinal basins in Dauphin County. The northern and larger outcrop lies between Mahantango and Berry Mountains and surrounds the Wiconisco coal basin. The southern outcrop lies between Peters and Second Mountains and is divided toward the east by Third Mountain. The southern limb of this outcrop traverses the northern part of Lebanon County. The Mauch Chunk in Dauphin and Lebanon Counties is about 3,000 feet thick⁸⁹, but this thickness may be repeated several times by folding in some places, particularly in the wide valley drained by Wiconisco Creek west of Short Mountain.

The Mauch Chunk consists largely of red shale but contains numerous beds of red, gray, and green sandstone which generally yield adequate supplies of good water through fractures and bedding planes. Because of its large areal extent the Mauch Chunk is probably the most important water-bearing formation in Dauphin County north of Kittatinny Mountain.

In the northern area of outcrop domestic wells in the Mauch Chunk generally range in depth from 70 to 120 feet and are reported to yield 5 to 30 gallons a minute. Three industrial wells in and near Millersburg 140 to 310 feet deep yield 10 to 30 gallons a minute. The strongest wells in the Mauch Chunk are the three drilled wells of the Millersburg Home Water Co. (1108-1110), which are 300 to 500 feet deep and yield 80 to 150 gallons a minute. Two of the wells flow a few gallons a minute, and the deeper well, yielding 150 gallons a minute, has a draw-down of 60 feet.

West of Short Mountain the Mauch Chunk outcrop is broad, owing apparently to repetition of the strata by folding, and as a consequence of the folding the rocks are well fractured and generally yield adequate supplies of water. In the vicinity of Loyaltown, however, where the Mauch Chunk outcrop is very narrow and apparently not complicated by minor folding, the rocks in some places are tight and relatively impermeable. Wells 1124, 1126, and 1127, near Loyaltown, are deep wells that yield only 3 to 5 gallons a minute with large draw-down. Well 1126 was drilled to 619 feet and encountered a little water at 60 and 400 feet, and although the depth to water level is only 14½ feet, it yields but 5 gallons a minute. Wells 1126 and 1127 were drilled to supply a creamery but had to be abandoned. In the southern outcrop of the Mauch Chunk, between Peters and Second Mountains, the wells are all used for domestic purposes and range in depth from 45 to 125 feet and in reported yield from 3½ to 12 gallons a minute, but all the wells were reported to yield adequate supplies of good water.

The analysis of water from well 1108, in the Mauch Chunk, shows a hardness of 148 parts per million, which indicates moderately hard water, but in general the water is reported to be rather soft.

⁸⁹ Ashley, G. H., personal communication.

Pocono sandstone.—The Pocono sandstone forms most of the long, narrow even-crested ridges in Dauphin County including Mahantango, Berry, Peters, and Second Mountains. Second Mountain also traverses northern Lebanon County. The Pocono also crops out over a wide area known as Broad Mountain, at the junction of Berry and Peters Mountains. A 4-foot bed of coal has been mined on Peters Mountain, which appears to be the lowest workable coal in the anthracite region.

The Pocono is relatively unimportant as a source of ground water in Dauphin and Lebanon Counties, as it crops out only on high ridges. However, it gives rise to small springs, and a few wells have been drilled into it, chiefly along Berry Mountain in Dauphin County. Well 1121, south of Elizabethtown, is 200 feet deep, flows 7 to 9 gallons a minute, and yields 50 gallons a minute with a draw-down of 60 to 75 feet after 36 hours pumping, despite the fact that it is drilled in a saddle at the summit of Berry Mountain. The analysis indicates very soft water, which is typical of waters from the Pocono, but the sample contained 3.4 parts per million of iron (Fe). Well 1122, at the foot of the hill, is 400 feet deep and flows only 3 gallons a minute. It was reported that no additional water was encountered in this well below a depth of 25 feet. The other wells recorded in the Pocono are shallow but yield adequate supplies for domestic use.

Catskill continental group.—The Catskill continental group has three separate outcrops in Dauphin County, one of which extends eastward through Lebanon County. The northern outcrop lies between Mahantango Mountain and the Northumberland County line. The middle and largest outcrop lies between Berry and Peters Mountains and extends eastward to Broad Mountain. The southern outcrop lies on the southern slope of Second Mountain and extends through Lebanon County into Schuylkill County. Willard⁹⁰ estimates that the thickness of the Catskill in this region cannot be more than 4,500 feet.

The Catskill is second in importance among the water-bearing formations in Dauphin County north of Kittatinny Mountain. The ground-water conditions in the Catskill north of Mahantango Mountain are set forth in the section of Montour and Northumberland Counties, (p. 199). In the large area of Catskill rocks between Berry and Peters Mountains there are a great many domestic and a few industrial and municipal wells, which obtain water almost wholly from beds of red or gray sandstone. Domestic wells in this region range in depth from 43 to 226 feet and are reported to yield from 3 to 25 gallons a minute of very good water. Well 1144, of the Halifax Borough Water Co. is 300 feet deep and yields 100 gallons a minute with moderate draw-down. The well yielded only 10 or 15 gallons a minute above a depth of 275 feet, but a bed of sandstone was encountered at this depth containing water under sufficient pressure to rise to a point 6 feet below the surface. The analysis of water from well 1142 shows it to be exceptionally low in dissolved mineral matter and very soft.

Chemung, Portage, Hamilton and Marcellus formations.—A few feet of Chemung rocks are reported in the western part of Dauphin County⁹¹. Portage, Hamilton and Marcellus are exposed in a small anticlinal area extending from Half Falls to a point about 3 miles east of Fisherville

⁹⁰ Ashley, G. H., personal communication.

⁹¹ Willard, Bradford, personal communication.

and in a narrow strip just north of Kittatinny Mountain extending eastward through Lebanon County.

No drilled wells were observed on the outcrop of these formations except the Portage but there may be a few on the northern outcrop.

Cayuga group and Clinton formation.—The Clinton formation is exposed on the north slope of Kittatinny Mountain in Dauphin and Lebanon Counties, but only a part of the Cayuga group is present.

Wells 1159 to 1161 were the only wells observed along the Cayuga-Clinton outcrop in Dauphin County. They are 39½ to 140 feet deep and yield about 5 gallons a minute each. As shown by the analysis, the water from well 1160 is moderately hard and yields a sediment containing 4.7 parts per million of iron (Fe). The Clinton sandstones are reported to be difficult to drill through owing to their extreme hardness.

Tuscarora sandstone and Juniata formation.—The Tuscarora sandstone forms the crest and southern slope of Kittatinny Mountain in Dauphin and Lebanon Counties. The Juniata formation crops out below the Tuscarora in Dauphin County but it does not appear in Manada Gap nor in any section farther east. Both formations are unimportant as sources of ground water in the area covered by this report.

ARTESIAN CONDITIONS

Very few flowing wells were reported or observed in Dauphin County and none were observed in Lebanon County. There are two flowing wells (1109 and 1110) in the Mauch Chunk east of Millersburg, and one (1129) in the Mauch Chunk at Erdman. However, in many of the wells the water level stands close to the surface—generally much above the point at which water was encountered.

QUALITY OF WATER

Analyses of five samples of water collected from four drilled wells and one spring in Dauphin County are tabulated at the end of the next page. The well waters are not unusual in composition, although the hardness ranges from 27 to 148 parts per million. The samples of water from wells 1121 and 1160, from the Pocono and Clinton, contained respectively 3.4 and 4.7 parts per million of iron (Fe). This amount of iron would be objectionable for certain industrial uses, such as laundry work, but may be removed by proper aeration. The water from spring 1201, in the Mauch Chunk shale south of Gratz, contained very little dissolved mineral matter of any kind. No samples of water were collected in Lebanon County.

PUBLIC SUPPLIES

The six public supplies in the northern part of Dauphin County using ground water are listed in the subjoined table. Lykens, Wiconisco, Williamstown, and Dauphin are all supplied with surface water, and the inhabitants of the villages are supplied by private wells and springs. There are no public supplies in that part of Lebanon County covered by this report.

DOMESTIC AND INDUSTRIAL SUPPLIES

Domestic water supplies in the northern part of Dauphin County are still obtained largely from dug wells, but springs and drilled wells are used in many places. Two creameries and two shoe companies have independent water supplies from drilled wells, but most of the industries are located in villages and use public water.

That part of Lebanon County covered by this report is mountainous and contains only a few scattered inhabitants, chiefly in Indiantown and Manada Gaps. No drilled wells were observed. Most of the people are supplied from small springs.

Analyses of waters in Dauphin County

[Analyst, M. D. Foster. Parts per million. Numbers less than 1200 correspond to numbers on map and in the table of well data]

	1108	1121	1142	1160	1201 ¹
Silica (SiO ₂) -----	17				
Iron (Fe) -----	.15	3.4		4.7	
Calcium (Ca) -----	50	10 ²	8 ²	24 ²	3 ²
Magnesium (Mg) -----	5.7				
Sodium (Na) -----	12	2.4 ³	1.2 ³	29 ³	4.1 ³
Potassium (K) -----	2.4				
Bicarbonate (HCO ₃) -----	120	40	11	26	19
Sulphate (SO ₄) -----	66	3 ²	2 ²	140 ²	1 ²
Chloride (Cl) -----	2.6	1 ²	4.0	10	1 ²
Nitrate (NO ₃) -----	2.1	.0	16	3.8	.0
Total dissolved solids -----	218	39 ³	41 ³	239 ³	19 ³
Total hardness as CaCO ₃ -----					
(calculated) -----	148	32 ⁴	27 ⁴	122 ⁴	9.0 ⁴
Date of collection (1931) -----	Aug. 31	Aug. 31	Aug. 31	Aug. 31	Aug. 31

¹ Spring 1 mile south of Gratz, in Mauch Chunk shale; temperature 50°F.

² By turbidity.

³ Calculated.

⁴ Determined.

Public water supplies in Dauphin County north of Kittatinny Mountain derived from ground water

Borough	Pop- ulation 1930	Owner	Source	Geologic source	Storage (gallons)	Average daily con- sumption	Treatment	Remarks
Elizabethville	1,341	Elizabethville Water Co. Inc.	Several small streams 2 drilled wells	Pocono	340,000	364 con- sumers	None	See wells 1121, 1122; analysis 1121. Also supplies 32 fire plugs.
Gratz	637	Gratz Water Supply Co., Inc.	One spring	Mauch Chunk	436,000	112 con- sumers	None	See analysis 1201. Also supplies 15 fire plugs.
Halifax	757	Halifax Borough Water Co.	3 springs 1 drilled well (auxiliary)	Pocono Catskill	470,000	49,000± gallons	Chlorine gas on well water	See well 1144. Also supplies 23 fire plugs. Springs on Pefers Mountain.
Loyalton	-----	Loyalton Water Co.	One spring	Mauch Chunk	675	22 con- sumers	None	Also supplies one creamery.
Millersburg	2,929	Millersburg Home Water Co.	7-8 springs 3 drilled wells	Pocono Mauch Chunk	1,000,000	170,000- 200,000 gallons	Chlorine gas	See wells 1108-1110, analysis 1108.
Uniontown (Pillow)	317	Uniontown Water Co.	3-4 springs 1 drilled well (auxiliary)	? Mauch Chunk	-----	300 con- sumers	None	See well 1112. Well drilled dur- ing drought of 1930 owing to low condition of springs.

Drilled wells in Dauphin County

No.	Location	Owner or tenant	Topographic situation	Altitude above sea level ² (feet)	Depth (feet)	Diameter (inches)	Principal water-bearing bed				Depth to which well is cased (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
							Depth to top of bed (feet)	Thickness (feet)	Character of material	Geologic horizon					
1102	Upper Paxton Twp. ½ mile north of Millersburg	Lykens Valley Sanitary Dairy Co.	Valley	400	160±	6	140	20	Hard gray sandstone	Mauch Chunk	-----	18±	10	I	Temperature of water 57° F.
1103	Millersburg	Hershey Creamery	do.	400	275	8	-----	-----	-----	do	-----	15	30	C	Considerable draw-down pumping 30 gallons a minute for 12 hours; water reported to be too hard for boiler use; temperature of water 54° F.
1104	Millersburg	Johnson-Baille Shoe Co.	do.	400	310	8	-----	-----	Sandstone	do	30	20	30	D&FP	Small draw-down pumping 30 gallons a minute for 10 hours; temperature of water 50° F.; reported to be too hard for boiler use.
1105	1½ miles north-east of Millersburg	Elmer Witmer	Knoll	580	83	5½	83	-----	Hard red sandstone	do	-----	18	-----	D	Adequate supply.
1106	½ mile south of Killinger	Reformed Church parsonage	Hillside	540	79	5½	69	10	Sandstone	do	10-12	44	-----	do	Do.
1107	½ mile south of Killinger	Killinger school	do.	540	92	5½	-----	-----	-----	do	-----	-----	-----	do	
1108	1½ miles east of Millersburg	Millersburg Home Water Co.	Valley	440	300	8	300	-----	Hard red sandstone	do	-----	20	80-90	PS	Draw-down 100 feet pumping 80-90 gallons a minute for 4 or 5 hours; see analysis 1108, very hard rock encountered in drilling; temperature 55° F. on Aug. 31, 1931.
1109	2½ miles east of Millersburg	Millersburg Home Water Co.	do.	440	500	-----	300 and 500 300	-----	Sandstone	do	-----	*	150	do	Small flow; draw-down 60 feet pumping 150 gallons a minute.
1110	2½ miles east of Millersburg	Millersburg Home Water Co.	do.	440	300	8	-----	-----	do	do	-----	*	100±	do	Small flow.

1111	Rife	C. F. Feidt	Knoll	580	112	58	106	12		do		30±	6	D	Draw-down about 75 feet pumping 6½ gallons a minute for 15 minutes.
	Mifflin Twp.														
1112	1 mile south of Pillow	Uniontown Water Co.	Hillside		296	58	236			do		100	63	PS	Draw-down 175 feet pumping 63 gallons a minute for 1 hour.
1113	Berrysburg	Mrs. L. Metz	Knoll	700	91	6				do			16	D	
1114	Berrysburg	Mrs. D. Lahr	do.	700	120	58	120		Red sandstone	do	15	30-40	6	do	Draw-down 20 feet pumping 6 gallons a minute.
1115	1 mile south of Berrysburg	W. Romberger	do.	660	97	6			do	do		40±		do	Adequate supply.
1116	2 miles southwest of Berrysburg	Irvin Deibler	do.	700	70-80	6				do				do	
	Washington Twp.														
1117	1 mile northeast of Rife	D. T. Strohecker	Hillside	580	106	6	106		Sandstone	do	3	34	9½	do	
1118	1½ miles northwest of Elizabethville	T. Herman	do.	600	99	6	99			do	15	16	30±	do	
1119	1½ miles north of Elizabethville	J. A. Herman	Knoll	640	111	6	95	5	Soft red shale	do	11	15	30±	do	Water occurs in soft shale below sandstone; depth to water level measured November, 1930.
1120	¾ mile north of Elizabethville	Mr. Zimmerman	do.	620	100	6	100			do	10	10	30	do	
1121	¾ mile southwest of Elizabethville	Elizabethville Water Co.	Ridge	1,020	200	8			Gray sandstone	Pocono		†	50	PS	Flows 7 to 9 gallons a minute; draw-down 60 to 75 feet pumping 50 gallons a minute for 36 hours; see analysis 1121, temperature 57° F. on August 31, 1931.
1122	¾ mile south of Elizabethville	Elizabethville Water Co.	Hillside	920	400	8			White sandstone	do	15±	do	3+	N	Flows 3 gallons a minute; no increase below depth of 25 feet.
1123	1 mile south of Loyaltton	Harry D. Swab	Knoll	600	102	6	60	10	Red sandstone	Mauch Chunk		25±	5±	D	Pumps dry in the summer.
1124	¾ mile west of Loyaltton	Daniel Romberger	do.	600	534	58	434		do	do	20	20	5	do	Draw-down 180 feet pumping 5 gallons a minute.
1125	¾ mile east of Loyaltton	John W. Boyer	Hillside	700	73	8	60	5		do	12	25-30	5±	do	
1126	¾ mile east of Loyaltton	Chas. I. Romberger	Slope	720	619	10-6	400		Sandstone	do	11	14½		N	Large draw-down; some water at depth of 60 feet; no additional water below 400 feet; depth to water measured August 21, 1931.

Drilled wells in Dauphin County—Continued

No.	Location	Owner or tenant	Topographic situation	Altitude above sea level ² (feet)	Depth (feet)	Diameter (inches)	Principal water-bearing bed				Depth to which well is cased (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
							Depth to top of bed (feet)	Thickness (feet)	Character of material	Geologic horizon					
1127	$\frac{1}{2}$ mile east of Loyalton Lykens Twp.	Chas. I. Romberger	Slope	720	285	6	-----	-----	Sandstone	Mauch Chunk	-----	16.1	$3\frac{1}{2}$	N	Depth to water measured Aug. 21, 1931.
1128	$\frac{3}{4}$ mile south-east of Pillow	Preston Troutman	Canyon	500	40	6	-----	-----	-----	Pocono(?)	-----	-----	-----	D	Flow measured August 22, 1931; temperature 54° F.
1129	Erdman	H. D. Klinger	Valley	540	23	6	-----	-----	-----	Mauch Chunk	-----	†	.56	do	
1130	$\frac{1}{4}$ miles east of Gratz Jackson Twp.	J. W. Rothermer	Knoll	780	72	-----	-----	-----	-----	do	-----	37±	-----	do	
1131	$\frac{1}{4}$ miles south-west of Elizabethville	Mountain House	Hillside	800	43	-----	-----	-----	-----	Catskill	-----	38±	-----	do	Dug well.
1132	1 mile north-west of Fisher-ville	O. Temple	Knoll	680	115	6	-----	-----	-----	Portage	-----	60	10-15	do	Red shale 100 feet, red sandstone 17 feet; draw-down 27 feet pumping 10 to 15 gallons a minute for 15 minutes; depth of water level measured August 27, 1931.
1133	$\frac{1}{2}$ mile north-west of Enders	S. Snyder	do.	700	150	6	140	10	Sandstone	Catskill	-----	40	-----	do	
1134	Enders	Thomas Huffman	Hillside	680	117	6	100	17	do	do	-----	45.97	10-15	do	

DAUPHIN COUNTY

	Jefferson Twp.																	
1135	Carsonville	J. Bordner	do.	760	110	6	90	20	do	do	-----	37.3	-----	do	Shale 50 feet, hard gray sandstone 40 feet, soft sandstone (water-bearing) 20 feet; depth to water level measured Aug. 27, 1931.			
	Wayne Twp.																	
1136	2 miles east of Enterline	J. A. Kinsinger	do.	700	98	6	85±	-----	do	do	15±	30±	3	do				
1137	Waynesville	F. L. Lebo	do.	600	87	5½	-----	-----	Hard sandstone	do	10±	40±	4-5	do	Pumps dry pumping 4 or 5 gallons a minute for 15 minutes; driller stopped drilling on account of hard rock.			
	Halifax Twp.																	
1138	½ miles south of Millersburg	Susquehanna Colliery Co.	do.	500	79	6	-----	-----	do	do	-----	4	-----	N				
1139	½ miles south of Millersburg	do.	do.	500	130	6	-----	-----	do	do	-----	4	-----	do	Yields adequate supply; abandoned because coal-storage plant was abandoned. Do.			
1140	¾ miles south of Millersburg	do.	Valley	400	39	6	-----	-----	Red shale	do	36±	36	-----	do				
1141	1½ miles north of Halifax	Mr. Reed	do.	380	50	6	-----	-----	Gravel and sand	Valley fill	30	10-12	5-6	D				
1142	Halifax	W. T. Willits Shoe Co.	do.	380	102	6	-----	-----	Red shale	Catskill	30	9.47	8½	B	Depth to water level and yield measured Aug. 31, 1931; depth to water level reported to be 2 feet in former years; water unfit for drinking owing to lack of seal at top of casing; see analysis 1142; temperature 57° F. on Aug. 31, 1931.			
1143	¾ mile north-east of Halifax	W. T. Willits	Knoll	500	226	6	125	-----	do	do	-----	110	-----	D				
1144	¾ mile east of Halifax	Halifax Borough Water Co.	Valley	440	300	8-6	275	25	Sandstone	do	50±	6	100	PS				
1145	1½ miles west of Powell Valley	Guy Bowman	Hill	600	97	6	95±	-----	do	do	28±	50	25	D	Moderate draw-down pumping 100 gallons a minute continuously; yielded only 10 to 15 gallons a minute above the 275-foot level. Water reported to be hard.			

Drilled wells in Dauphin County—Concluded

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No.	Location	Owner or tenant	Topographic situation *	Altitude above sea level ² (feet)	Depth (feet)	Diameter (inches)	Principal water-bearing bed				Geologic horizon	Depth to which well is cased (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
							Depth to top of bed (feet)	Thickness (feet)	Character of material							
1146	Reed Twp. Inglenook	McFadden & Hoff	Valley	340	116	6	-----	-----	Sandstone	Catskill	-----	-----	-----	-----	D	
1147	Middle Paxton Twp. Speeceville	W. H. Culver	do.	360	108	6	70	10	Soft sandstone	Mauch Chunk	20?	30	5	do		Supplies 5 homes.
1148	$\frac{1}{2}$ mile east of Speeceville	R. L. Manning	Hillside	440	125	6	-----	-----	Shale and sandstone	do	-----	-----	-----	do		Water reported to be hard; temperature 50° F. on Aug. 31, 1931.
1149	0.3 mile east of Zionsville	E. J. Stackpole, Jr.	Valley	400	62	6	-----	-----	do	do	-----	6	12	do		Has another well 85 feet deep yielding 9 or 10 gallons a minute.
1150	0.3 mile south of Zionsville	W. Minsker	Hillside	400	75	8	75	-----	do	do	12	6	10	do		Moderate draw-down pumping 10 gallons a minute.
1151	$\frac{3}{4}$ mile north of Dauphin	Paxton Consolidated School	Knoll	500	145	-----	-----	-----	do	do	-----	-----	-----	do		
1152	$\frac{3}{4}$ mile west of Dauphin	C. W. Miller	Valley	340	74.8	6	60	14.8	Red sandstone	do	18-20	12	3 $\frac{1}{2}$	do		Pumps dry pumping 3 $\frac{1}{2}$ gallons a minute.
1153	0.3 mile northeast of Dauphin	I. L. Schaeffer	do.	360	70	6	70	-----	do	do	6	6	-----	do		Adequate supply.
1154	$\frac{3}{4}$ mile southwest of Stone Glen	H. E. Kennedy	do.	360	72	8	68	2	do	do	-----	7	9	do		Draw-down 7 feet pumping 9 gallons a minute for 3 hours.
1155	Stone Glen	Helen Weist	do.	380	45 \pm	-----	-----	-----	-----	do	-----	-----	-----	do		Dug 10 feet; dug well went dry.
1156	$\frac{1}{2}$ mile east of Heckton Mills	M. S. Moss	Knoll	500	191	-----	190 \pm	-----	-----	Portage(?)	-----	75-80	-----	do		Adequate supply.
1157	$\frac{3}{4}$ mile southeast of Heckton Mills	Harrisburg Country Club	do.	460	260	8	360	-----	Red sandstone	do	-----	60-112	25	D&L		Depth to water level 60 feet during winter, 112 feet during summer of 1930, draw-down 52 feet pumping 25 gallons a minute for 12 hours.

GROUND WATER

1158	$\frac{3}{4}$ mi'e southeast of Heckton Mills Susquehanna Twp.	do.	do.	460	85					do			20	N	Abandoned because it could be pumped dry in 4 hours pumping 20 gallons a minute.
1159	1 $\frac{1}{4}$ miles north-east Rockville	Susan J. Potter	Canyon	720	81	6			Red shale and sand-stone	Cayuga				D	Red shale occasionally produces muddy water.
1160	Rockville	J. C. Hoover estate	Valley	340	140	6			Hard sand-stone	Clinton(?)		14 \pm	5 \pm	do	See analysis 1160; draw-down about 11 feet pumping about 5 gallons a minute for 10 or 15 minutes; see below.
1161	Rockville	do.	do.	340	39.4	6			do	do		-14.52		N	Depth to water level measured Aug. 23, 1931; was 23.52 feet Aug. 31, while pump on adjacent well was operating.

* 2 feet above ground.

† Flows.

¹ If no distance is given, well is in town.

² Generally determined from nearest contour line or bench mark on topographic map.

³ B—Boiler; C—Cooling; D&FP—Drinking and fire protection; D—Domestic; D&L—Domestic and lawn; I—Industrial; N—None; PS—Public supply

LACKAWANNA COUNTY

GENERAL FEATURES

[Area 451 square miles; population 310,397]

Lackawanna County is situated in the north-central part of the area covered by this report. It ranks second in population among the counties of this area but ranks first in density of population, with 688 inhabitants to the square mile. Six of the 20 largest municipalities in the area are in the Wyoming Valley in Lackawanna County—Scranton, with 143,433 inhabitants, the largest city in northeastern Pennsylvania; Dunmore, 22,627; Carbondale, 20,061; Old Forge, 12,661; Olyphant, 10,743; and Taylor, 10,428. The population is largely concentrated in the Wyoming Valley, which contains the rich Northern anthracite field. In 1930 there were 65 anthracite mines in Lackawanna County, and in 1929 there were 353 manufacturing establishments with annual products valued at \$5,000 or more each. In 1930 there were 1,500 farms in the county, chiefly on the northwest side of Wyoming Valley.

SURFACE FEATURES

The two highest points in Lackawanna County are Big Shiny Mountain, in Spring Brook Township, and Big Pine Hill, in Lehigh Township, each 2,320 feet above sea level. The lowest point in the county, where Lackawanna River crosses the Luzerne County line, is 620 feet above sea level, so that the maximum relief is 1,700 feet. The northern part of Wyoming Valley traverses the county from northeast to southwest and is bordered on both sides by high ridges, the Lackawanna and Bald Mountains, to the northwest, and the Moosic Mountains, to the southeast, uniting to form the "prow of the canoe" along the Wayne-Susquehanna County line. Northwest of Lackawanna River the mountains rise abruptly to a sharp ridge which in most places is somewhat higher than the country to the northwest, so that most of the drainage in this part of the county flows westward by way of Tunkhannock Creek. Southeast of Lackawanna River the rise is more gradual, the crests of the high mountains are several miles from Lackawanna River, and large streams like Roaring Brook have cut deep canyons through the mountains. In general the country southeast of the river is higher and more rugged than that to the northwest. The floor of the northern part of Wyoming Valley has not the flatness that is characteristic of it in Luzerne County but consists of an irregular chain of low hills 200 to 300 feet high through which the river has cut a rather narrow, rocky channel in some places and built up a narrow flood plain in others.

With the exception of small areas along the eastern and southern borders Lackawanna County is drained entirely by the North Branch of Susquehanna River, chiefly through one of its larger tributaries, Lackawanna River, which flows through the center of the county. The southernmost part of the county is drained by Lehigh River, and the east slope of the Moosic Mountains, along the Wayne County border, is drained by Lackawaxen River, a tributary of Delaware River.

GEOLOGY AND GROUND WATER

GENERAL SECTION

Lackawanna County was completely covered with ice during the last continental glaciation. The general direction of ice movement, as observed from striae on bare rock surfaces in Abington and other townships, was S. 35°-40° W. Glacial drift covers the entire county except where subsequent erosion has removed it. In Waverly and vicinity the drift mantle is 250 to 300 feet deep in some places. Thick deposits of glacial outwash occur in places along Lackawanna River, and are 50 to 100 feet thick near Dickson, Scranton, and Moosic⁹².

The rock formations exposed in Lackawanna County range from the post-Pottsville down to the Damascus formation of the Catskill group.

Generalized section for Lackawanna County

Geologic formation	Maximum thickness exposed (feet)	Character of rocks	Ground-water conditions
Glacial drift (Wisconsin)	300	Clay, sand, and gravel; till and outwash.	Yields small supplies of potable water to dug wells.
Post-Pottsville formations	950±	Hard sandstone and slate; 11 workable coal beds.	Unimportant as a source of potable ground water owing to mining operations.
Pottsville formation	200±	Chiefly coarse white sandstone and conglomerate; one coal bed (not workable); carbonaceous black shale near base containing plant remains.	Unimportant as a source of ground water owing to character and small area of outcrop. Three flowing wells reported.
Mauch Chunk shale	150±	Greenish shale and thin-bedded sandstone.	Unimportant as a source of ground water, owing to character and small area of outcrop. No wells reported.
Pocono sandstone	650±	Hard, massive grayish or yellowish-white sandstone; gray, green, and red shales; and massive yellowish-white, very coarse conglomerate.	Yields moderate supplies of potable water, but crops out only in small area. Several flowing wells near Carbondale.
Catskill group	1,000±	Chiefly greenish-gray crossbedded sandstone and red shale; one bed of red sandstone near middle.	Yields moderate to large supplies of potable water; supplies nearly all drilled wells in the county. Some salty water.

STRUCTURE

The only important structural feature in Lackawanna County is the Lackawanna syncline, which traverses the county in a southwesterly direction. This syncline enters the county at the northeast corner as a narrow, shallow trough, gradually deepens and broadens toward the southwest and reaches its maximum development in Luzerne County. The dips of the rim rocks rarely exceed 10° to 20° within the county but steepen considerably to the southwest. The rim rocks, the Pottsville formation and Pocono sandstone, form a rather simple syncline, but the

⁹² Darton, N. H., Sand available for filling mine workings in the northern anthracite basin of Pennsylvania; U. S. Bur. Mines Bull. 45, pl. 1, 1913.

core rocks, the post-Pottsville formations, are folded into a series of minor anticlines and synclines which trend about N. 70° E. Toward the southwest this course is about parallel to the sides of the basin, but the gentle curving of the basin toward the north causes the courses of the folds to become more and more oblique, so that near the northeast end of Lackawanna County a few scattered folds cross the basin at an angle of about 45°.

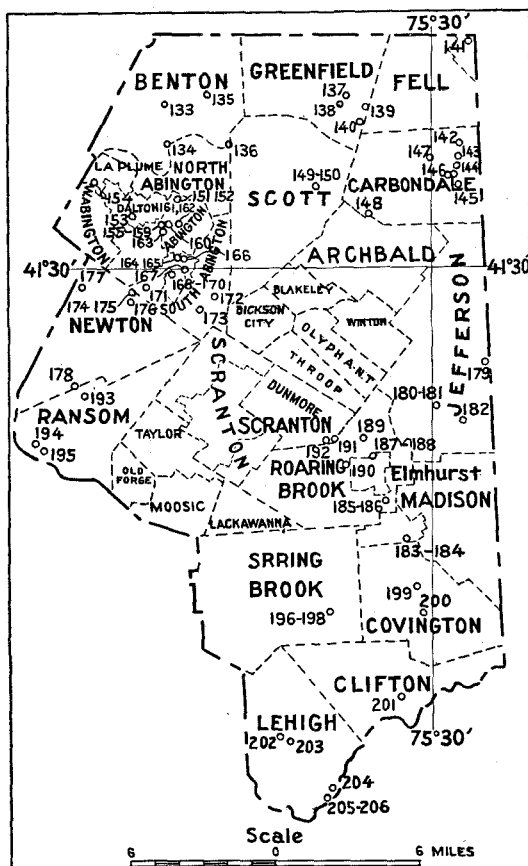


Figure 10. Map of Lackawanna County showing location of water wells

The Milton anticline in Lackawanna County is a gentle fold that passes through Waverly and Tompkinsville and gradually dies out.

The rocks in the northwestern and southeastern parts of the county are in general nearly horizontal.

WATER-BEARING FORMATIONS

[See pp. 41-53 for further description]

Glacial drift.—The glacial drift furnishes small supplies of potable water to numerous shallow dug wells throughout the higher regions lying outside the Lackawanna Valley. The water table generally lies close to the surface and gives rise to numerous small springs, many of which are utilized. So far as is known, there are no drilled wells in the county

that obtain water from the glacial drift. A drilled well $1\frac{1}{4}$ miles west of Fleetville (well 135) encountered 250 feet of drift on the top of a rounded hill, and a drilled well in Waverly (well 157) encountered 300 feet of drift. No wells were reported to obtain water from the glacial outwash along Lackawanna River, and the water contained in the sand and gravel is likely to be contaminated by mine drainage and sewage.

Post-Pottsville formations.—Before the advent of coal mining the post-Pottsville formations occupying Lackawanna Valley were doubtless good water-bearing formations, but at present nearly all the water contained in them is pumped out as mine drainage, and the water is unfit for ordinary use. The coal beds are generally sufficiently fractured to allow free movement of ground water. The lower beds are spoken of as “drier” than the upper ones, and most of the water in them comes down the bedding planes from the outcrop. Much of the water in the upper levels seeps down from the surface, for mining is carried on beneath the river and streams. Several old artesian wells used in the early days were spoiled as mining proceeded, and at the present time these formations are not important as sources of potable ground water.

Pottsville formation.—The Pottsville formation crops out around the Lackawanna syncline as a subordinate ridge beneath a higher ridge of Pocono sandstone. Only three wells (141, 147, and 148) were reported to have penetrated the Pottsville in Lackawanna County. These wells were all reported to be flowing wells when drilled, but it is not known whether the wells still flow or are still usable. Well 147 is cased down through the overlying coal beds. In general the Pottsville is not an important source of ground water in the county because of its small area of outcrop along a rather inaccessible ridge.

Mauch Chunk shale.—The red shales that characterize the Mauch Chunk in the counties to the south thin out toward the northeast corner of the region and disappear entirely along the north end of Lackawanna Valley. They interfinger with and are gradually replaced by green shales and flaggy sandstones. The Mauch Chunk is unimportant as a source of ground water within this county, because it has a very small area of outcrop, between two high ridges. No wells were reported in the Mauch Chunk within the county, but it is an important source of ground water in Luzerne County.

Pocono sandstone.—The Pocono sandstone forms the crests of the Moosic Mountains and Bald Mountain and crops out along both rims of Lackawanna Valley.

Relatively few wells have been drilled into the Pocono in this county, because most of its outcrops are forested ridges. On the slope of the Moosic Mountains about $1\frac{1}{2}$ miles east of Carbondale there are four deep wells in the Pocono or the Catskill (142 to 145), three of which are reported to flow. It is probable that other strong flowing wells could be obtained along the flanks of Lackawanna Valley, but the abundant supply of surface water from small mountain streams is adequate for the requirements of the valley and most of the wells formerly used for public supply have been abandoned.

Catskill continental group.—The Catskill continental group underlies the greater part of Lackawanna County, comprising all the region north-

west and southeast of Lackawanna Valley. The Mount Pleasant formation covers most of this area, but the Elk Mountain and Cherry Ridge formations crop out in the southeastern and northwestern corners of the county, and in addition the Honesdale and Damascus formations crop out at the northwest corner.

The Catskill contains numerous beds of water-bearing sandstone, one or more of which are usually encountered in wells of moderate depth. Many of the thin-bedded sandstones, such as those which are quarried for flagstones, contain numerous bedding planes, which allow movement of ground water. In some places the permeability of the sandstone is doubtless due to porosity, but in general the permeability is due to joints and bedding planes. Because it underlies most of the county and supplies nearly all the drilled wells, the Catskill is the most important water-bearing formation in Lackawanna County. In most of the wells the water stands somewhat above the level at which it was first encountered, but only a few flowing wells were reported. The water from the Catskill is generally of very good quality, but a deep well in Dalton (well 153) struck salty water and had to be plugged at a depth of 275 feet. The yield of wells in the Catskill ranges from a few gallons to more than 300 gallons a minute and seems to increase with depth in localities where the structural conditions are favorable.

ARTESIAN CONDITIONS

The structure of the rocks along the flanks of the Lackawanna syncline is favorable in most places for artesian wells, and flowing wells have been obtained locally from rocks of the Pottsville, Pocono, and Catskill. In many of the wells, however, the water is not under sufficient artesian head to flow, and most of the drilled wells in the higher regions have to be pumped.

It is reported that prior to the advent of coal mining there were many artesian wells on the floor of Lackawanna Valley, but that mining activities gradually spoiled all these wells.

The monthly operating water-level measurements taken by the Clarks Summit Water Company on well 168 are listed below. The heavy draw-down during parts of 1929 is attributed to an increased pumping rate, but a uniform rate of pumping was maintained from August 1930 to August 1931. These measurements are of interest in showing the recovery in March 1931 from the drought of 1930. The measurements were made monthly by means of a submerged air line and pressure gage, while the pump was operating continuously.

Monthly measurements of depth to water level, in feet, in well 168, Clarks Summit

Month	1929	1930	1931	Month	1929	1930	1931
January -----	159	155	163	July -----	153	153	127
February -----	166	155	160	August -----	155	159	129
March -----	164	155	133	September -----	157	159	
April -----	139	155	124	October -----	152	159	
May -----	144	155	121	November -----	150	160	
June -----	144	155	118	December -----	152	162	

QUALITY OF WATER

Analyses of the seven samples of water collected in Lackawanna County are tabulated at the top of page 134. The six samples from wells ending in the Catskill were not unusual in composition. Their hardness ranged from 93 to 162 parts per million. The sample from a spring in the glacial drift contained less dissolved mineral matter and was rather soft. The iron content of all the samples was very low. Analyses of water from the other rock formations are not available, but with the exception of the mine waters in the coal basin and one other exception noted below the ground water is reported to be of good quality.

Well 153, about 550 feet deep, in Dalton, encountered a strong flow of salt water from the Catskill. The well was plugged at a depth of 275 feet, and a moderate flow of potable water was obtained. It is therefore possible that salty water may be encountered in other deep wells in this section of the county, particularly near the deep Lackawanna syncline.

PUBLIC SUPPLIES

The five communities in Lackawanna County that are supplied wholly or largely from ground water are listed in the subjoined table. All the large cities and boroughs in the county are in Lackawanna Valley and are supplied with surface water by the Scranton Spring Brook Water Co. The company owns several drilled wells, but in 1930 very little ground water was being used. The Carbondale division of this company has several flowing wells (142 to 145), which discharge into a reservoir and augment the surface water supply. The people in most of the villages obtain their water from private wells and springs.

DOMESTIC SUPPLIES

In the rural parts of the county, chiefly the northwestern and southeastern parts, domestic supplies are still obtained largely from dug wells and springs, although the number of drilled wells is steadily increasing. In the vicinity of Waverly several large estates and country clubs are supplied by deep drilled wells.

INDUSTRIAL SUPPLIES

The chief industrial use of ground water is in the Lackawanna Valley, where water pumped from the coal mines is used for washing the coal. Three creameries use ground water for bottle washing and boiler feed. The Delaware, Lackawanna & Western Railroad formerly used considerable water from drilled wells near Nay Aug station, but these wells have been abandoned. The railroad still utilizes drilled wells in Clarks Summit, however. (See well 170.) The Hillside Home of the Scranton poor district has several strong drilled wells near Clarks Summit. (See wells 174-176.) In some places the hardness of the water necessitates softening for use in boilers.

Public water supplies in Lackawanna County derived from ground water

Community	Population 1930 ¹	Owner	Source	Geologic source	Storage (gallons)	Average daily consumption	Treatment	Remarks
Chinchilla	-----	Ray Pembridge	3 springs and 1 drilled well	Springs in Glacial drift, well in Catskill	-----	40-50 consumers	None	Supplies only a portion of town; see well 172, analysis 172.
do	-----	Mrs. W. C. Hall	1 spring	Glacial drift	30,000	50 consumers	do	Supplies only a portion of town, see analysis 1202. See well 168.
Clarks Summit	2,604	Clarks Summit Water Co.	2 drilled wells	Catskill	350,000	270,000 gallons	do	See well 168.
Dalton	1,072	do	1 flowing well	do	250,000	60,000 gallons	do	See well 153.
Moscow	892	Moscow Water Co.	La Touche Creek, springs, and 1 drilled well	do	1,225,000	?	?	See well 183.
Waverly	-----	Waverly Water Co.	2 drilled wells	do	68,000	20,000 gallons	None	Also supplies 10 fire plugs; see wells 158, 159, analysis 159.

¹ Figures available only for incorporated places.

Drilled wells in Lackawanna County

No.	Location ¹	Owner or tenant	Topographic situation	Altitude ² (feet)	Depth (feet)	Diameter (inches)	Character of water-bearing material	Geologic horizon	Length of casing (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
	Benton Twp.												
133	Fleetville	Benton Township High School	Hillside	1,260	294	6	-----	Catskill	90	80±	40	D	First water encountered at a depth of 200 feet.
134	Wallsville	Woodlawn Dairy	do.	1,060	242	8	Sandstone and shale	do	40	40	25±	I	Small draw-down pumping 35± gallons a minute for 24 hours; water reported to be very soft.
135	1½ miles east of Fleetville	Woodlawn Manor Farms	Hilltop	1,320±	500	8	-----	do	250	160—	18	do	Small draw-down pumping 18 gallons a minute for 24 hours; water reported to be moderately hard; see analysis 135; Temp. 51° F. Sept. 17, 1930; farms have another well with similar yield 250 feet deep.
136	¾ mile south-east of East Benton Greenfield Twp.	Mr. Norton	Valley	1,050	16	-----	Valley fill	Glacial drift	16	-----	-----	D	Driven well.
137	3½ miles north-west of Carbondale	John Booth, Inc.	Upland	1,650	16	-----	Blue clay	do	-----	Sometimes flows	25	I	Dug well; small draw-down pumping 25 gallons a minute indefinitely.
138	do.	M. S. Russel	Hillside	1,700	170	-----	-----	Catskill	5-10?	At surface	-----	D	Also uses a dug well.
139	3 miles north-west of Carbondale	W. A. Russel	Valley	1,550±	90	6	Grey sandstone	do	18	Flows	30	do	Flowing well, 24 pounds pressure; numerous springs in this vicinity; see analysis 139; Temp. 50° F. Sept. 17, 1930.
140	do.	W. Gardner	do.	1,600	108	3	-----	do	5-10?	30±	3.3	do	Flowing well; temperature 49° F.
	Fell Twp.												
141	Near Forest City	Temple Coal Co.	do.	-----	1,100	8	Conglomerate	Pottsville	25±	Flows	-----	I °	Weak flow; would probably yield more with pumping; exact location not known.

Drilled wells in Lackawanna County—Continued

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No.	Location ¹	Owner or tenant	Topographic situation	Altitude ² (feet)	Depth (feet)	Diameter (inches)	Character of water-bearing material	Geologic horizon	Length of casing (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
142	Carbondale Twp. 1½ miles north-east of Carbondale	Seranton Spring Brook Water Co.	Ravine	1,300±	Probably 588-800	6	-----	Pocono or Catskill	-----	Flows	-----	P S	"Reynshanhurst" well; flowing.
143	1½ miles east of Carbondale	do.	Hillside	1,650±	800±	8	-----	do	None	do	-----	do	Two wells (1 and 2) identical, 2,000± feet apart, same altitude; flowing.
144	1½ miles south-east of Carbondale	do.	Canyon	1,580	700±	8	-----	do	do	do	-----	do	Well 3; flowing well.
145	2 miles south-east of Carbondale	do.	Ravine	1,680	500	8	-----	do		Below surface	-----	do	Well 4; well 5 not listed is 740 feet deep.
146	1½ miles south-east of Carbondale	O. J. Ransom [redacted]	Slope	1,600	20.1	24	Sand	Glacial drift	20.1	7.50	-----	N	Dug well; depth to water level measured Sept. 16, 1931; see pl. 4.
147	Carbondale	Hendricks Manufacturing Co.	Valley	1,100±	500	10-8	Conglomerate and gray sandstone	Pottsville	250	Flows	-----	I c	Reported to flow.
148	Near Jermyrn Scott Twp.	Jermyrn Borough Water Co. (original owner)	Hillside	-----	750	8	-----	do	Shallow	do	-----	N	Reported to flow; exact location not known.
149	1½ miles north of Montdale	Mr. Avery	do.	-----	314	6	-----	Catskill	195	90	15	D	Small draw-down pumping 15 gallons a minute.
150	1½ miles north of Montdale Abington Twp.	M. Boshak	Lakeside	1,580	175	-----	-----	do		Below surface	6	do	

GROUND WATER

151	1½ miles north-east of Waverly	George Myers	Valley	1,200	14	-----	Drift	Glacial drift	-----	11	-----	do	Dug well; dry in summer.
152	do.	Jesse Palmer	do.	1,200	150	8	Sandstone and shale	Catskill	18	5	5	do	Draw-down 17 feet pumping 260 gallons a minute for 10 minutes; reported to be hard water.
153	Dalton	Clark Summit Water Co.	do.	1,040	550±	8	-----	do	-----	5-6 above surface	40-80±	PS	Plugged at a depth of 275 feet; salt water and hydrogen sulphide below 275 feet; some hydrogen sulphide above 275 feet; on opening valve, flows 80± gallons a minute for 2 hours, 60± gallons a minute for 3 hours; 40 gallons a minute after 8 hours.
154	LaPlume	Dr. F. V. Serio	Hilltop	-----	300±	6	-----	do	-----	20±	-----	D	Dug well; depth to water level measured Sept. 16, 1931; see pl. 4.
155	Waverly	Howard Stone	Hillside	1,320	13.9	24	-----	Glacial drift	13.9	6.10	-----	N	
156	do.	Mr. Palmer	do.	-----	152	6	-----	Catskill	Shallow 300	-----	-----	N	Well occasionally flows.
157	do.	Waverly Community House	do.	1,320	351	6-8	Gray sandstone	do	-----	Below	52	do	Small draw-down pumping 72 to 78 gallons a minute for 8 hours.
158	do.	Waverly Water Co.	do.	1,300	319	8	-----	do	80	35	72-78	PS	
159	do.	do.	do.	1,300	450	4	-----	do	100	50±	-----	do	Auxiliary well; see analysis 159; temp. 50° F. Sept. 17, 1930.
160	do.	C. Evans	Hilltop	1,400±	382	8	Sandstone and red shale	do	30	150-160	100	D	Draw-down 10 feet pumping 100 gallons a minute for 2 days.
161	¾ mile east of Waverly	Paul Belin	Hillside	1,300±	679	-----	Gray sandstone	do	27	-----	-----	do	Yields only 35 gallons in 10 hours.
162	do.	Ed. Warren	do.	1,260±	348	-----	-----	do	200	-----	Very small 75	do	
163	¼ mile south of Waverly	Waverly Country Club	do.	1,300±	307	-----	Red and gray sandstone	do	46	-----	-----	do	
	South Abington Twp.												
164	0.6 mile north of Clarks Green	Parker Bros.	do.	1,400	550	-----	Sandstone	do	6	55	-----	do	

Drilled wells in Lackawanna County—Continued

No.	Location ¹	Owner or tenant	Topographic situation	Altitude ² (feet)	Depth (feet)	Diameter (inches)	Character of water-bearing material	Geologic horizon	Length of casing (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
165	$\frac{1}{2}$ mile north of Clarks Green	D. T. Lansing	Hilltop	1,420	402	-----	Gray sandstone and red shale	Catskill	7-8	202±	50	D	Small draw-down pumping 50 gallons a minute.
166	do.	W. L. and R. B. Mathews, Inc.	Upland	1,380	260	6	-----	do	-----	50	83	I	Hard water; see analysis 166; temperature 53° F., Sept. 17, 1930.
167	Clarks Green	House of Good Shepherd	-----	1,360±	450	8	-----	do	-----	360	80	D	
168	Clarks Summit	Clark Summit Water Co.	Upland	1,260	247	8	-----	do	40	144	87½	PS	Two wells, same depth; draw-down 44 feet pumping 87½ gallons a minute 24 hours a day; see water levels on p. 124.
169	do.	H. Carpenter	do.	1,260	197	6	Red shale and sandstone	do	98	Flows	15	D	Flowing well.
170	do.	D. L. & W. R.R.	do.	1,260	250	12	-----	do	-----	-----	-----	R	Two wells, same depth, 300 feet apart.
171	1.1 miles southwest of Clarks Summit	Mr. Nevin	Hilltop	1,360±	95	4	Blue sandstone	do	13	10	13	D	Draw-down 3 feet pumping 13 gallons a minute for half an hour.
172	$\frac{1}{2}$ mile northeast of Chinchilla	Ray Pembridge	Hillside	1,300	368±	6	Red sandstone and shale	do	-----	-----	30	PS	See analysis 172; supplies a large group of homes; temperature 52° F., Sept. 17, 1930.
173	Chinchilla	W. A. Adams	Valley	1,040	625	-----	-----	do	-----	175(?)	-----	D	
	Newton Twp.												
174	1½ miles southwest of Clarks Summit	Hillside Home, Scranton poor district	Upland	1,260+	502	-----	-----	do	-----	56	105	H	Draw-down 8 feet pumping 105 gallons a minute for 6 hours.
175	do.	do.	do.	1,340±	457	6	-----	do	-----	357-	100	do	See analysis 175; temp. 51° F. Sept. 17, 1930.
176	2 miles southwest of Clarks Summit	do.	do.	-----	582	12	-----	do	-----	-----	25-30	do	
177	$\frac{1}{2}$ mile northwest of Schultsville	E. H. Stanton	Hilltop	1,200	30.6	-----	Drift	Glacial drift	-----	26.6	-----	D	Water level measured July 24, 1930; never dry; dug well.

178	Milwaukee Jefferson Twp.	J. W. Kipple	Hillside	1,180	143	6	Red shale	Catskill	100	40	24	do	Small draw-down pumping 24 gallons a minute for 5 minutes; also has dug well 30 feet deep, 15 feet to water; never dry.
179	1½ miles north-west of Maplewood	T. Mitchel	Hillside	1,580	63	6	-----	do	Shallow	25	-----	do	Pumps dry pumping 3.3 gallons a minute for 20 minutes.
180	Mount Cobb	Robt. Clemens	-----	1,654	70	6	Sandstone	do	11	15±	60	do	Small draw-down pumping 60 gallons a minute for 1 hour.
181	do.	L. Strockbein	-----	1,654	122	6	do	do	63	22	-----	do	First water encountered at a depth of 110 feet in red shale below sandstone.
182	Wimmers Madison Twp.	Thomas Samuel	Hillside	1,593	84	6	Hard conglomerate	do	22	40	Small	do	Large draw-down pumping 20 gallons a minute for half an hour.
183	Moscow	Moscow Water Co. (Original owner)	do.	1,600±	405	6	Shale and some conglomerate	do	Shallow	100	75	PS	First water 100 feet below the surface.
184	do. Roaring Brook Twp.	-----	-----	-----	140	4	Gravel resting on gray sandstone	Glacial drift	140	40±	-----	D	
185	1½ miles south-east Elmhurst	Mr. Higgins	Hillside	1,700	64	-----	-----	Catskill	-----	-----	-----	do	
186	do.	Herbert Ruth	do.	1,700	66	6	-----	do	-----	18	-----	do	
187	Elmhurst	E. A. Vogal-bacher	do.	1,450	100	60	Red shale	do	45	30	6	do	Draw-down 67 feet pumping 6 gallons a minute for 1 hour.
188	do.	do.	do.	1,400±	80-90	-----	-----	do	40-50	40±	6	do	Draw-down within 3 feet of bottom pumping 6 gallons a minute for 1 hour.
189	1½ miles north-west Elmhurst	Frolic Cafe	do.	1,400	130	-----	Grey shale and sandstone	do	60	75±	-----	do	
190	1 mile west Elmhurst	Keymacher	Hilltop	1,700	125	-----	Hard gray, green, and red flagstones	do	Shallow	30	10±	do	

Drilled wells in Lackawanna County—Continued

No.	Location ¹	Owner or tenant	Topographic situation	Altitude ² (feet)	Depth (feet)	Diameter (inches)	Character of water-bearing material	Geologic horizon	Length of casing (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
191	Nay Aug	Delaware Lackawanna & Western R. R.	Hillside	1,238 to 1,380	584 to 2,000	7=15" 1=12"	Sandstone	Catskill	22 to 200	343 to 505	Average 175 Maximum 343 Minimum 120	N	Eight drilled wells on hill above Nay Aug Station; see log.
192	do.	Scranton Spring Brook Water Co.	Canyon	1,129 to 1,137	460 to 1,000	8 and 10	do	do	-----	-----	-----	do	Seven drilled wells along creek near Nay Aug; one well flows continuously, others intermittently; some hydrogen sulphide; all seven wells reported to yield about 2,000,000 gallons a day by pumping.
193	Ransom Twp. 0.4 mile south-east of Milwaukee	L. F. Richards	Hillside	1,040	140	6	-----	Catskill	Shallow	60±	-----	D	Water level 20 feet below surface when well was 100 feet deep, but pumped dry; now has small draw-down pumping 75 gallons a minute for half an hour. Small draw-down pumping 90 gallons a minute for 4 days.
194	Ransom	W. Hughes	Valley	600	130±	8	Gray sandstone and red shale	do	18	50	75	do	
195	½ mile south-east of Ransom Spring Brook Twp.	Ransom Hospital	do.	620	227	8	Gray sandstone	do	70	14±	90	H	
196	Spring Brook	Arthur Stevens	Upland	1,600	300	6	Sandstone and red shale	do	12	-----	-----	D	Flowing well at depth of 285 feet with water level 15± feet above ground; water lost at 300-foot depth.

197	do.	William Griffith	do.	1,600	700	6	-----	do	10-12	-----	-----	N	Drilled for mineral test; now abandoned.
198	do.	Mrs. E. Thomas	do	1,600	92	6	-----	do	10	30±	-----	D	
Covington Twp.													
199	Daleville	Mr. Schwartz	Hillside	1,850	92	6	-----	do	40	39±	-----	do	Large draw-down; dry in summer; dug well.
200	1½ miles south of Daleville Clifton Twp.	Mr. Wardell	Upland	1,820	17±	-----	Drift	Glacial drift	-----	-----	-----	do	
201	1.6 miles north-east of Clifton Lehigh Twp.	Miss Anna L. Kaufman	Hilltop	1,840	113	-----	-----	Catskill	-----	60±	-----	do	
202	Bear Lake	Mr. Wolf	Lakeside	1,900	209	6	Red and green sandstone	do	36	19	-----	do	
203	¾ mile east of Bear Lake	C. F. Stegmaier	Upland	1,820	200	6	Red shale	do	60	50	25-30	do	
204	¾ mile north of Thornhurst	T. E. Jones	Hillside	1,590	77	6	-----	do	20	20	5-6	do	Small draw-down pumping 25 to 30 gallons a minute.
205	Thornhurst	Clinton Heller	Valley	1,560	50	6	-----	do	10	25±	-----	do	
206	do.	Methodist Church	do.	1,580	101	6	-----	do	4-6	30-40	-----	do	Dug wells in Thornhurst encounter "quicksand" at a depth of 20 to 25 feet.

¹ If no distance is given well is in town.

² Generally estimated from nearest contour line or bench mark on topographic map.

³ D—Domestic; H—Hospital; I—Industrial; N—None; PS—Public Supply; R—Railroad.

^c It is not known whether this well is still in use.

Analyses of waters in Lackawanna County

[Parts per million. Numbers less than 1200 correspond to numbers on map and in the table of well data]

	135	139	159	166	172	175	1202 ¹
Silica (SiO ₂)	12			11	9.8		
Iron (Fe)	.62			.04	.04		
Calcium (Ca)	37	31	41	50	25	34	
Magnesium (Mg)	5.0	3.7	5.6	9.0	8.6	4.4	
Sodium (Na)	15	1 ²	10 ²	13	7.2	6 ²	
Potassium (K)	2.2			2.4	3.0		
Bicarbonate (HCO ₃)	168	102	140	197	126	128	52
Sulphate (SO ₄)	4.5	5 ³	9 ³	11	9.7	5 ³	11 ³
Chloride (Cl)	2.2	3.0	7.0	7.0	1.2	2.0	2.0
Nitrate (NO ₃)	.15	3.0	16	2.5	.05	2.8	
Total dissolved solids	162	101 ²	163 ²	199	121	121 ²	62 ²
Total hardness as CaCO ₃ (calculated)	113	93	125	162	98	103	
Date of collection (1930)	Sept. 17	Sept. 17	Sept. 17	Sept. 17	Sept. 17	Sept. 17	Sept. 17

¹ Spring 1¼ miles northeast of Chinchilla, glacial drift; temperature 51°F.

² Calculated.

³ By turbidity.

Analysts: 139, 159, 175, K. T. Williams; 135, 166, 172, 1202, L. A. Shinn.

Log of Delaware, Lackawanna & Western Railroad well 2, near Nay Aug

[Well 191 on p. 132 and map. Surface altitude 1,291 feet]

	Feet		Feet		Feet
Clay and boulders	0-43	Sandstone, red	330-358	Sandstone, light	533-537
Fine gravel	43-58	Sandstone, gray	358-365	Sandstone, gray	537-546
Hardpan and boulders	58-101	Sandstone, red	365-371	Shale, red	546-552
Blue clay	101-112	Shale, red	371-375	Sandy shale	552-565
Sticky clay	112-128	Sandstone, red	375-381	Sandstone, gray	565-581
Gravel and clay	128-135	Sandstone, light	381-389	Sandy shale, red	581-587
Sticky clay	135-170	Shale, red	389-407	Sandstone, red	587-596
Sandstone, gray	170-174	Sandstone, light	407-419	Sandstone, gray	596-618
Shale, broken	174-178	Sandstone, red	410-426	Sandstone, red	618-627
Shale, red	178-205	Conglomerate, red	426-430	Sandstone, gray	627-633
Sandstone, green	205-218	Sandy shale, red	430-449	Sandstone, light	633-644
Sandstone, gray	218-239	Sandstone, red	449-452	Sandstone, gray	644-653
Sandstone, light	239-251	Sandstone, gray	452-461	Sandstone, light	653-662
Sandstone, gray	251-268	Sandy shale, red	461-472	Sandstone, gray	662-671
Shale, red	268-287	Sandy shale, gray	472-480	Sandstone, green	671-673
Sandy shale, red	287-300	Sandstone, gray	480-499	Sandstone, gray	673-679
Shale, green	300-304	Shale, red	499-509	Shale, red	679-682
Sandstone, gray	304-309	Sandstone, gray	509-522	Sandstone, red	682-716
Sandstone, green	309-330	Shale, red	522-533		

LUZERNE COUNTY

GENERAL FEATURES

[Area 892 square miles, population 444,409]

Luzerne County is about in the center of the area described in this report and is bordered by Sullivan County at the northwest corner. It is by far the largest county in the area and has a greater population than any other county in the area. With 498 inhabitants to the square mile Luzerne County is second in density of population only to Lackawanna County. Of the 20 largest municipalities in the area described in this report 6 are in Luzerne County—Wilkes-Barre, 86,626; Hazleton, 36,765; Nanticoke, 26,043; Kingston, 21,600; Pittston, 18,246; and Plymouth, 16,543. The centers of population and industrial development are the anthracite fields, foremost of which are the Northern field in the Wyoming Valley and the Eastern Middle field at Hazleton. In 1929 there were in the county 411 manufacturing establishments with products valued at \$5,000 or more each, and in 1930 there were 102 anthracite mines and 2,385 farms. The farms are scattered in the higher regions on both sides of the Wyoming Valley.

SURFACE FEATURES

The highest point in Luzerne County is on the western border of Fairmount Township, at the corner of Luzerne, Sullivan and Columbia Counties where North Mountain reaches a maximum altitude of 2,450 feet. Southeast of Susquehanna River Penobscot Knob and Bald Mountain are each 2,140 feet above sea level. The Susquehanna at Berwick is 480 feet above sea level and therefore, the maximum relief in the county is 1,970 feet. The greatest local relief is around North Mountain, which rises 1,000 to 1,200 feet above the surrounding country.

A portion of the eastern and southeastern part of Luzerne County is drained by the headwaters of Lehigh River. The remainder and by far the greater part of the county is drained by the North Branch of Susquehanna River, which flows southwestward through about the center of the county. In flowing 42 miles from Ransom to Berwick the North Branch drops 40 feet—a gradient of 1.05 feet to the mile.

GEOLOGY AND GROUND WATER

GENERAL SECTION

The rock formations exposed in Luzerne County range from the post-Pottsville formations, of Pennsylvanian age, down to the Onondaga formation, of Middle Devonian age. Outcrops of the Helderberg limestone reach the southwestern boundary of the county but do not extend beyond it. The Wisconsin terminal moraine crosses the southern part of the county (see pl. 1), and the greater part of the county is covered by glacial drift. Extensive deposits of glacial outwash occur along Susquehanna River and less extensive deposits along the smaller streams.

Generalized section for Luzerne County

Geologic formation	Maximum thickness (feet)	Character of rocks	Ground-water conditions
Glacial drift (Wisconsin)	300±	Till consisting of clay and boulders, with sand lenses, outwash consisting of stratified clay, sand, and gravel.	Till yields small supplies to shallow wells. Outwash yields moderate to very large supplies. Yields water of excellent quality to numerous small springs. Outwash in Susquehanna Valley yields water of less desirable quality.
Post-Pottsville formations (of Pennsylvanian age)	1,800±	Sandstone, conglomerate, shale, fireclay, carbonaceous "slate" and coal, a few beds of limestone.	Unimportant as water bearer; head lowered and water polluted by mining operations.
Pottsville formation	500±	Chiefly hard coarse quartz conglomerate, with gray, red brown, and green sandstones, "slate", and a few thin seams of coal.	Yields moderate to large supplies of water of good quality. Many flowing wells.
Mauch Chunk shale	2,000±	Chiefly red shale, with red and green sandstone and green shale.	Yields adequate supplies of water to shallow domestic wells, and moderate to large supplies to deep drilled wells, especially in the Hazleton region. Some flowing wells. Water is of good quality.
Pocono sandstone	600±	Coarse and in places pebbly gray and yellowish-gray sandstone, flaggy sandstone, and greenish-gray sandstone; thin seams of coal may be found locally.	Yields moderate supplies of water to wells of moderate depth, some of which are flowing wells. With one exception, water is of good quality.
Catskill group	1,700±	Red shale, red and gray cross-bedded sandstone, gray, green, and white sandstone, gray shale and sandstone in lower part.	Yields moderate supplies of water to wells of moderate depth. Few flowing wells. Water is of good quality.
Chemung formation and Portage group	3,100±	Alternating gray and olive-green shale and sandstone, dark shale at base; fossiliferous; marine.	Yields small supplies of water. Deeper wells likely to obtain salty or brackish water. Water generally hard and may give off hydrogen sulphide.
Hamilton formation	1,000±	Brown, gray, and bluish-gray sandy shales; fossiliferous; marine.	Yield small supplies of potable water. Water usually hard, likely to be high in dissolved mineral matter, chiefly sulphate, and likely to give off hydrogen sulphide.
Marcellus shale	410	Black and dark-blue fissile shales; fossiliferous; marine.	
Onondaga formation	10-15	Limestone.	Unimportant.

STRUCTURE

Nearly all of Luzerne County lies in the Valley and Ridge province, in which the rocks have been strongly folded. In going from north to south across the county, five major folds are encountered, all of which trend northeast. The first of these is a shallow syncline on the crest of North Mountain, forming the Mehoopany coal basin. The second is the Milton anticline, which exposes the Portage group in the northwestern part of the county and gradually flattens out toward the northeast. The third and most pronounced is the Lackawanna syncline, which

has preserved the post-Pottsville formations throughout the Wyoming Valley. The maximum depth of this syncline is reached in the vicinity of Wilkes-Barre and Plymouth. The double rim of this syncline is formed by the resistant Pottsville formation and Pocono sandstone, separated by the less resistant Mauch Chunk shale. The fourth fold is the Berwick (Montour) anticline, which exposes a few feet of the Onondaga formation in the vicinity of Beach Haven. This fold reaches its maximum development farther west, and only the eastern portion reaches Luzerne County. The fifth major fold comprises a series of anticlines

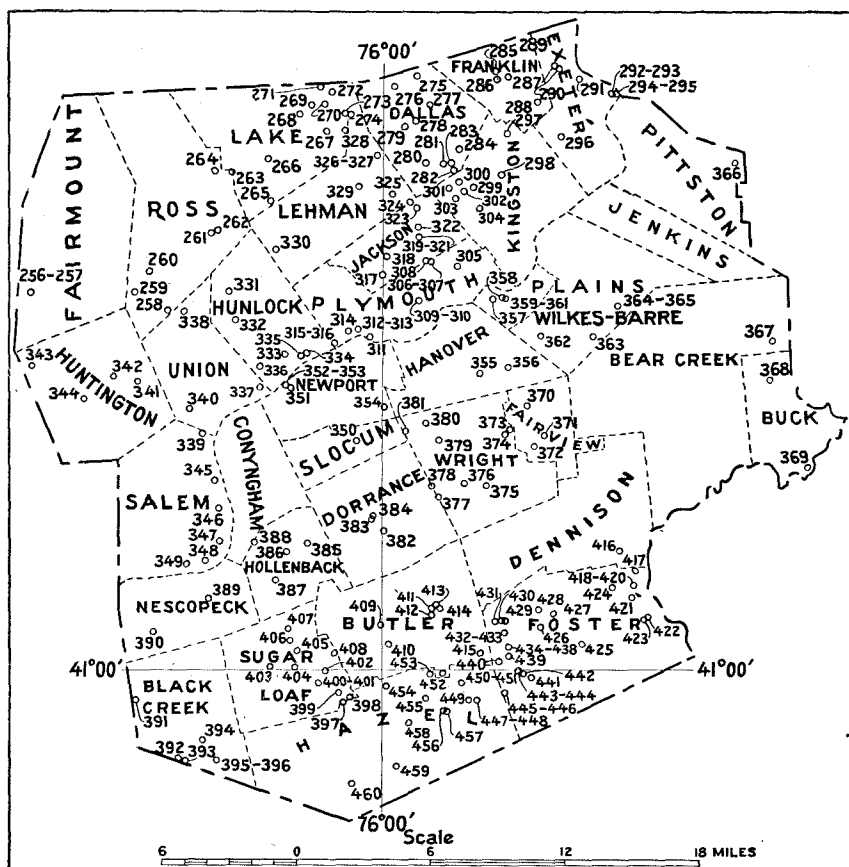


Figure 11. Map of Luzerne County showing location of water wells. Laurel Run Twp. name omitted (wells 362-3). South boundary of Plains Twp. runs from L in Plains to B in Barre. Well 339 is in Union Twp.

and synclines forming the Eastern Middle anthracite field in the vicinity of Hazleton. The synclinal basins in this region are relatively shallow, and there are large areas from which all the coal beds have been eroded.

The general dips of the region are 0° to 40° , and the maximum dips are found on the rims and within the synclinal coal basins. Although these synclines are relatively simple canoe-shaped folds as viewed in a general way, the relatively soft post-Pottsville beds in their cores are severely folded and contorted, with numerous minor faults. The north-

ern and the easternmost parts of the county border the Appalachian Plateaus province and are characterized by horizontal or nearly horizontal strata.

WATER-BEARING FORMATIONS

[See pp. 41-59 for further description]

Glacial drift.—The terminal moraine left at the end of the Wisconsin glaciation crosses the southern part of the county from a point west of Beach Haven to the southeast corner on Lehigh River. North of this line the county is covered by glacial drift except where erosion has exposed the underlying bedrock.

On both sides of Susquehanna River the unsorted till and the stratified outwash material yield small to moderate supplies of potable water to shallow dug wells, and where lenses of gravel occur stronger supplies are obtainable. In the smaller rural communities dug wells and springs in the glacial drift are the chief sources of domestic water supply, and many of these springs are used for small public supplies. The drift waters are exceptionally low in dissolved mineral matter. (See analyses on p. 165.)

Very few drilled wells end in the glacial drift in Luzerne County, but many of them penetrate 20 to 200 feet of drift before reaching the underlying bedrock. In many of these drilled wells lenses of water-bearing sand and gravel are cased off. In some places the glacial drift is composed largely of clay or "hardpan" and may yield little or no water.

Along Susquehanna River, particularly in the Wyoming Valley, there are thick deposits of glacial outwash consisting of irregular lenses of stratified clay, sand, and gravel. The river flows over a buried valley in many places, and buried channels are encountered in mining operations. Near Beach Haven, where the terminal moraine crosses Susquehanna River, there are at least three terraces, two of which are visible in plate 2-B. The buried valley of the Susquehanna in the Wyoming Valley has been studied by Darton⁹³, who found that the glacial outwash deposits reached a maximum depth of 309 feet near Plymouth. (See fig. 4.)

Moderate supplies of water are obtained by dug and driven wells in the glacial outwash deposits, and exceptionally large supplies are obtained in a few places by means of drilled wells equipped with well screens or strainers. An excellent example of proper well construction is furnished by the three gravel-walled and screened wells of the Stanton Operating Co., of Pittston, which are by far the strongest wells noted in northeastern Pennsylvania. (See well 294). A cross section of well 1 is shown in figure 5, and the wells are described on pages 33-35. Each well was tested at 1,280 gallons a minute with a draw-down of only 9 or 10 feet after 8 hours continuous pumping. (See also wells 295, 353). Doubtless many more wells of this type could be developed in the county. The Horn Dairy Co., of Wilkes-Barre, obtains an adequate supply of water from outwash sand by means of a driven well only 45 feet deep (well 358). An analysis of water from this well shows that the water is high in nitrate, and this would probably be true of other wells obtaining water from outwash deposits within the coal basin.

Post-Pottsville formations.—The post-Pottsville formations, including the Allegheny and part of the Conemaugh, crop out in the Wyoming

⁹³ Darton, N. H., Sand available for filling mine workings in the northern anthracite basin of Pennsylvania. U. S. Bur. Mines Bull. 45, p. 6. 1913.

Valley, where their combined thickness is about 1,800 feet. All of the Conemaugh formation has been swept away by erosion in the Hazleton region, and only about 700 feet of the Allegheny formation remains in the deepest (Hazleton) basin.

The coal and sandstone beds are well fractured and in most places contain considerable water. However, in the coal basins mine drainage has lowered the water level considerably, and the oxidation products resulting from the exposure of the coal to air in the mines have rendered the water unfit for ordinary use in most places. According to Mr. Paul Sterling, engineer of the Lehigh Valley Coal Co., Wilkes-Barre, most of the ground water occurs within about 450 feet of the surface, and the lower beds are usually dry. Individual collieries in the Wyoming Valley pump from 1,500 to 2,500 gallons a minute on a yearly average, and those in the Hazleton basin pump from 500 to 8,000 gallons a minute. According to Mr. Sterling, 17 to 20 tons of water is pumped for every ton of coal mined. Mine drainage water is used only for washing coal.

Despite the drainage and pollution several wells obtain satisfactory supplies of potable water from sandstone beds in the Wyoming Valley. (See wells 357, 361.) Well 361 yields water containing hydrogen sulphide.

Pottsville formation.—The Pottsville formation crops out as a high strike ridge surrounding the Wyoming Valley coal basin and is also exposed around and between the small coal basins in the Hazleton region. Its thickness around the Wyoming Valley averages about 220 feet and varies between 150 and 300 feet. In the Hazleton region the Pottsville formation is about 500 feet thick, and the conglomerate is considerably coarser than it is in the Wyoming Valley. Thin beds of coal occur in the Pottsville in both regions, but few of them are of workable thickness.

The six wells believed to penetrate the Pottsville around the Wyoming Valley are reported to yield large supplies of potable water, and all the wells for which data are available are said to be flowing wells. The water occurs in open fractures and crevices in the hard conglomerate and sandstone, and the artesian head is probably due to the presence of thin shale beds above the fractured conglomerate. Most of these wells were formerly used for municipal supply but have been abandoned in favor of larger surface-water supplies.

In the Hazleton region numerous drilled wells (chiefly for municipal supply) penetrate the Pottsville, though many of these wells extend down into the underlying Mauch Chunk shale. In many wells it is not certain whether the water comes from the Pottsville or from sandstone beds in the Mauch Chunk, and in some the water probably comes from beds of both formations. These wells range in depth from 150 to more than 800 feet, and most of them yield from 50 to 150 gallons a minute, although a few yield as little as 10 gallons a minute. The wells in the Hazleton region show great variation in water level. Many of the wells flow during wet seasons, and during dry seasons the water level drops far below the surface. (See pp. 160-163.)

On the basis of three analyses the water from the Pottsville formation appears to be of good quality. It is very soft and contains a relatively small amount of dissolved mineral matter.

Mauch Chunk shale.—The Mauch Chunk shale has two areas of outcrop in Luzerne County. It crops out in a long, narrow valley between

ridges of the Pottsville formation and the Pocono sandstone around the Wyoming Valley, and in the large valley area drained by Nescopeck Creek and Lehigh River. In the western part of the Wyoming Valley the Mauch Chunk is about 400 feet thick, but it thins rapidly to the northeast, and the red beds gradually disappear, giving way to about 150 feet of greenish shale and thin-bedded sandstones. In the southern part of the county the Mauch Chunk is about 2,000 feet thick.

The Mauch Chunk yields adequate supplies of potable water to numerous shallow farm wells 50 to 250 feet deep in the southern part of the county. Large supplies are obtained from the Mauch Chunk in the Hazleton region by wells that reach it after penetrating the overlying rocks. Some of these wells that encounter sandstone beds yield more than 100 gallons a minute, and many of them flow during the winter. Like the water in the other non-marine formations, that in the Mauch Chunk contains very small amounts of dissolved mineral matter and is rather soft.

Pocono sandstone.—The Pocono sandstone is the principal mountain maker of the county. Its horizontal strata cap the high North Mountain and its tilted strata form the outer and highest ridge surrounding the Lackawanna syncline and the highest ridge (Nescopeck Mountain) north of the Hazleton coal basin.

Most of the wells that obtain water from the Pocono sandstone in Luzerne County are along the north rim of Wyoming Valley. In the vicinity of West Nanticoke there are several shallow flowing wells in the Pocono, some of which supply water for bottling. The highest reported yield for any of these wells is 20 gallons a minute, but it is probable that greater yields are obtainable. The water from the Pocono is as a rule noticeably low in dissolved mineral matter, but the water from well 334, at Hunlock Creek, contains 393 parts per million of total dissolved solids, principally sodium chloride and sodium bicarbonate.

Catskill continental group.—The Catskill continental group underlies most of the county north and southeast of the Wyoming Valley and crops out in two strips about 1½ miles wide around the Berwick (Montour) anticline.

Because of its great areal extent the Catskill supplies more drilled wells than any other formation in the county, generally with an adequate supply of good water. The water is generally of good quality but salty or brackish water such as was obtained in well 256, is likely to be encountered by deep wells in the western part of the county north of the river.

Chemung formation and Portage group.—In Luzerne County the Portage group is deeply buried in most places and crops out only along the Milton anticline and around the Berwick (Montour) anticline, and a few feet of marine Chemung are present near Beach Haven.

The Portage is a rather poor water-bearing formation in this county. Domestic wells in the Portage yield from 2 to 10 gallons a minute. The water is generally hard, and some of it gives off an odor of hydrogen sulphide. An analysis of water from well 342 showed 224 parts per million of total dissolved solids, chiefly calcium bicarbonate and sodium chloride, and a hardness of 110 parts per million. However, most of the shallow drilled wells in the Portage yield water that is satisfactory for domestic purposes.

Hamilton formation, Marcellus shale and Onondaga formation.—The Hamilton formation and Marcellus shale have a very small area of outcrop in Luzerne County, being exposed only along the core of the Berwick (Montour) anticline between Nescopeck and Dorrance, and the Onondaga formation is present only near Beach Haven.

This group of formations is much like the Portage group both in lithology and in water-bearing properties. Most of the wells end in shale or "slate" and have small yields. A few wells obtain somewhat more water from beds of fractured sandstone. No water samples were collected from this group of formations within the county, but samples taken in other counties and reports within the county indicate that the water is likely to contain a large amount of dissolved mineral matter, is generally high in sulphate, is generally hard, and in many places gives off hydrogen sulphide.

ARTESIAN CONDITIONS

In many of the wells penetrating the hard-rock formations the water stands somewhat above the level at which it was first encountered. In some wells the artesian head is sufficient to produce a flow. The deep synclinal coal basins are the structural features that produce nearly all the flowing wells in Luzerne County. Several flowing wells occur around the Wyoming Valley, but not every well adjacent to the valley is a flowing well, for locally the confining beds may allow the water to escape into overlying formations. The wells in the small synclinal coal basins in the Hazleton region are noteworthy for their great seasonal variations in artesian head. Many of the wells flow during the winter, but during the summer the water level may drop to a point several hundred feet below the surface of the ground. This is probably due to the fact that all the wells are relatively close to the catchment areas of the formations from which they draw water. Thus the wells continue to flow only as long as the catchment areas continue to be supplied by rainfall.

QUALITY OF WATER

Eighteen samples of water were collected from Luzerne County, 12 from drilled wells and 6 from springs, the analyses of which are tabulated on page 165. The waters from drilled wells contain moderate or small quantities of dissolved mineral matter and are generally soft. The sample from a well in Hunlock Creek in the Pocono sandstone (well 334) was soft but contained 393 parts per million of total dissolved solids, most of which was sodium chloride and sodium bicarbonate. The other analyses of water from the Pocono sandstone show negligible amounts of these constituents and but small amounts of dissolved mineral matter.

The samples from springs, all of which are in glacial drift, contained very little dissolved material and were very soft.

No analyses were made of drainage waters from coal mines, but it is reported that such waters may be very acid, presumably from the pyrite rather than from the sulphur contained in the coal⁹⁴. With the exception of the post-Pottsville formations all the rock formations above the Portage yield water of good quality. The water from the Portage and older formations is satisfactory for most purposes but is likely to contain more dissolved mineral matter and to have greater hardness than water from

⁹⁴ Leitch, R. D., Acidity of drainage from high pyritic coal areas in Pennsylvania. U.S. Bur. Mines Rept. Inv. 2146, p. 9, Jan. 1932.

the overlying formations. Deep wells may encounter brackish or salty water in the region north of Wyoming Valley (see well 256), but no brackish or salty water has been reported south of the valley. In many places water from the Portage and underlying formations contains a small quantity of hydrogen sulphide but nowhere in amounts large enough to be objectionable.

A driven well in Wilkes-Barre (well 358) obtains water from the glacial outwash that has a hardness of 198 parts per million and contains considerable chloride and nitrate. This is not characteristic of water in the glacial drift of the higher and more sparsely populated regions and may be due to the large amounts of mine drainage and sewage which are discharged into Susquehanna River above Wilkes-Barre, chiefly from Lackawanna River⁹⁶.

PUBLIC SUPPLIES

The larger cities in Luzerne County depend entirely on surface water, Wilkes-Barre and surrounding towns in the Wyoming Valley being supplied by the Wilkes-Barre division of the Scranton Spring Brook Water Co. The water is obtained from numerous small streams impounded on both sides of the valley. The Wyoming Valley Water Co. supplies Hazleton and the nearby Hudsonale, Bear Creek, Wolffs Run, Barnes Run, Mount Pleasant, and a small part of Harleigh. This company also obtains its water from numerous small streams fed by springs.

The communities supplied by ground water are tabulated below. The water from supplies for which analyses are available is low in dissolved mineral matter, soft, and satisfactory for domestic and industrial use. Of the 22 ground-water supplies tabulated, only one is treated for sanitary reasons. The water from spring supplies is noticeably low in dissolved mineral matter and is comparable in this respect to the surface water used for public supply.

INDUSTRIAL SUPPLIES

Ground water is used by a variety of industries in Luzerne County. Perhaps the largest industrial use is in coal washing, in which a large quantity of mine drainage water is used. At times, particularly during dry seasons, the water pumped from the mines is insufficient to supply this need, and additional water is pumped from wells. Both surface water and ground water are used to supply the boilers in the collieries. A large quantity of ground water derived from glacial outwash is used for cooling in the generation of electric power. Ground water is also used for bottling, for swimming pools, and for washing bottles and cooling in dairies.

DOMESTIC SUPPLIES

Domestic supplies in the more thickly settled parts of Luzerne County lying outside of the coal basins are derived largely from drilled wells. In the rural communities the proportion of drilled wells to dug wells is steadily increasing, because many of the dug wells are reported to be unreliable during dry seasons and subject to contamination.

⁹⁶ See Leighton, M. O., Quality of water in the Susquehanna River drainage basin; U.S. Geol. Survey Water-Supply Paper 108, pp 23-31, 1904.

Public water supplies in Luzerne County using ground water

Community (Population 1930 ¹)	Owner	Source	Geologic source	Storage (gallons)	Average daily con- sumption	Treatment	Remarks
Bear Creek	Bear Creek Water Co.	3 springs	Glacial drift	11,000	² 27 consumers	None	See analysis 1206.
Conyngham, 522	Conyngham Water Co.	Spring, tun- nel, and 1 drilled well (auxiliary)	Mauch Chunk	-----	120 consumers	None	See analysis and well 401. Tunnel driven 550 feet into mountain cement-lined.
Dallas, 1,188	Dallas Water Co.	2 springs and 4 drilled wells	Glacial drift and Catskill	150,250	90,000 gallons	None	See wells 278, 279, 280, 284; analysis 278.
Derringer, Fern Glen, and Gowen	Wyoming Valley Water Supply Co.	Streams and 1 drilled well (auxiliary)	Pottsville	100,000	³ 201 consumers	-----	See well and analysis 394. Well used only during dry summer. 50 percent of water consumed by inhabitants, 50 percent by coal washer; sup- plies 7 fire hydrants.
Drifton	do.	3 drilled wells; two- thirds of supply is surface water from Eckley	Mauch Chunk	⁴ 275,000	⁵ 300,000 gallons	None	Connected with Eckley and in part with Highlands; chiefly surface water. See wells 415, 440; analysis 415.
Eckley	do.	Streams and 2 drilled wells (auxiliary)	-----	-----	⁶ 165,000 gallons	-----	Connected with Drifton.
Ebervale, Jeddo, (440) Japan, Middletown, Oakdale, Har- leigh	Jeddo Highland Coal Co.	10 drilled wells	Pottsville and Mauch Chunk	⁷	266 consumers	-----	All towns connected together. See wells 442 to 451. Harleigh supplied in part by surface water from Wyoming Valley Water Co.
Freeland-South Heberton, Alvintown, Upper Lehigh (Freeland 7,098)	Freeland Water Co.	Springs and 10 drilled wells	do.	225,000	285,000 gallons	Chloride of lime 36 oz. 24 hours	See wells 429 to 438; analysis 435. Has 3 plants, uses only 1 (Freeland) and keeps 2 in reserve.
Glen Summit	Wyoming Valley Water Supply Co.	1 spring	Glacial drift	400,000	37,500 gallons	None	See analysis 1207.
Harding	Barrett Water Co.	1 spring and 1 drilled well	Glacial drift and Catskill	200,000	23 consumers	None	See analysis 1203.

Public water supplies in Luzerne County using ground water—Continued

Community (Population 1930 ¹)	Owner	Source	Geologic source	Storage (gallons)	Consumers	Treatment	Remarks
Alderson (Harveys Lake)	A. L. Stull	1 spring	Glacial drift	125,000	10	None	
Avon Inn (Harveys Lake)	N. Raskin	1 drilled well	Catskill	2,000	4	None	See well 270.
Lake (Harveys Lake)	Lake Improve- ment Co.	1 spring	Glacial drift	30,000	30		
Laketon (Harveys Lake)	Laketon Water Co.	1 drilled well	Catskill	-----	30-40	None	See analysis and well 269.
Worden Place (Harveys Lake)	W. S. Kitchen	do.	do.	15,000	75	None	
Highlands	Jeddo Highland Coal Co.	2 drilled wells	Pottsville	238,000	3 63		See well 426.
Lattimer and Milnesville	Pardee Bros. Coal Co.	9 drilled wells	do.	85,000	125	None	Colliery uses most of water. See wells 452-454.
St. Johns	J. O. Williams	3 springs		580,000	14	None	
Shavertown	Shavertown Water Co.	3 drilled wells and 1 spring	Catskill and glacial drift	5,500		None	See wells 283, 300, 301; analysis 301. Daily consumption 60,- 000-70,000 gallons.
Trucksville	C. D. Hazeltine	2 drilled wells and 4 springs	Catskill and glacial drift	20,000	200	None	Supplies only part of town; part supplied by Rust & Dow, Trucksville Gardens supplied by C. A. Leighton. See wells 302, 304; analysis 1204.
Wopwallopen	Citizens Water Co.	3 springs	Glacial drift	15,000	50	None	See analysis 1205.
White Haven, 1,537	White Haven Water Co.	2 groups of springs and 2 drilled wells (auxiliary)	Glacial drift and Mauch Chunk	-----	350	None	See analysis 1208.

¹ Population figures not available for unincorporated towns.² Including 1 lighting plant.³ Including 1 coal washer.⁴ 75,000 gallons reserve tank for fire, 125 pounds pressure.⁵ 200,000 gallons from Eckley.⁶ Figure for 1920.⁷ Five reservoirs, 70,000 to 8,000,000 gallons.

Drilled wells in Luzerne County

No.	Location ¹	Owner or tenant	Topographic situation	Altitude ² (feet)	Depth (feet)	Diameter (inches)	Character of water-bearing material	Geologic horizon	Length of casing (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
256	Fairmount Twp. Fairmount Springs	E. G. Smith	Valley	1,200	1,500	6	Red sandstone	Catskill	453	25±	large	N	Drilled for oil; large yield of salt water in red sandstone between 316 and 361 feet; cased to 453 feet to shut off salt water; no record kept of any water encountered below the salt water; see log.
257	do.	do	do	1,200	36	6	-----	do	-----	25±	-----	D	
258	Ross Twp. ¾ mile south-east of Bloomingdale	Bloomingdale Church	Hillside	1,140±	75	6	-----	Portage	18	18	7	do	Large draw-down pumping 7 gallons a minute.
259	¼ mile south of Irish Lane	Elias Long	Valley	1,160	99	-----	Gray sandstone	do	16	50	5	do	
260	0.9 mile north of Irish Lane	Robert Shaw	Hillside	1,220	104	6	Sandstone	do	72	50	4-5	do	Bedrock overlain by 72 feet of "hardpan".
261	½ mile north of Sweet Valley	Frank Oliver	Lakeside	1,360	206	6	-----	do (?)	13	60	40	do	Small draw-down pumping 40 gallons a minute.
262	½ mile north of Sweet Valley	Community Well	do	1,340	174	6	-----	Catskill	125	30	40	do	Small draw-down pumping 40 gallons a minute; bedrock overlain by 125 feet of drift on east side of North Lake; wells in the vicinity of Sweet Lake are 125 to 175 feet deep; average depth to bedrock 150 feet.
263	½ mile south-east of Weintz	D. Wesley	Ridge	1,360	102	6	-----	do	40-50	-----	-----	do	Adequate supply.
264	Weintz	L. Bowman	Hillside	1,340	115	6	Hard green-gray, and red sandstone	do	6	35	30	do	Small draw-down pumping 30 gallons a minute.

Drilled wells in Luzerne County—Continued

No.	Location ¹	Owner or tenant	Topographic situation	Altitude ² (feet)	Depth (feet)	Diameter (inches)	Character of water-bearing material	Geologic horizon	Length of casing (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
	Lake Twp.												
265	Pike Creek	M. L. Ruggles	Hillside	1,180	100	6	Gray sand-stone	Catskill	51	32	75	D	Small draw-down pumping 75 gallons a minute for one hour.
266	Loyalville	Loyalville School	Upland	1,280	156	6	do	do	72	40	12	do	Draw-down 20 feet pumping 12 gallons a minute for a long period.
267	1 mile north-east of Outlet	Rev. Mr. Aleksiw	Hillside	1,300	140	6	Red sand-stone	do	18	16	9	do	Pumps dry at 9 gallons a minute.
268	0.4 mile south-west of Laketon	Sandy Beach Improvement Co.	do	1,320	230	6	Gray sand-stone	do	52	50	20	do	Small draw-down pumping 20 gallons a minute.
269	0.3 mile north of Laketon	Laketon Water Co.	Near hilltop	1,440	278	8	Red sand-stone	do	2	135	-----	P S	Supplies several cottages; see analysis 269; temperature 51° F., Sept. 16, 1950.
270	1.4 miles south-west of Alderson	N. Raskin	Hillside	1,240	295	4	-----	do	200+	105	-----	do	Two dug wells nearby are 36 and 42 feet deep.
271	1.4 miles west of Alderson	Mr. Oliver	do	1,240	295	4	Gray sand-stone	do	180	30	20	D	Draw-down 10 feet pumping 20 gallons a minute for a long period; "hardpan" and clay 100 feet, boulders and "quick sand" 80 feet, bedrock (considerable gray sandstone) 60 feet.
272	$\frac{3}{4}$ mile west of Alderson	Mr. Reddington	Hilltop	1,449	491	-----	-----	do	8	90	15	do	Draw-down 40-50 feet pumping 15 gallons a minute for a considerable period.
273	0.8 mile north of Lake	Mr. Higgs	Hillside	1,340	350	8	Gray sand-stone	do	18	30	22	do	Small draw-down pumping 22 gallons a minute all day.
274	$\frac{3}{4}$ mile north of Lake	W. S. Kitchen	do	1,360	250	6	-----	do	-----	50	7	P S	Water reported to be soft.

275	Dallas Twp. 1.1 miles north- east of Kunkle	Cory Myers	Saddle	1,280	215	6	Red and gray sand- stone	Catskill	96	-----	-----	D	Bedrock and water at 148 feet.
276	Kunkle	J. Morratt	Hillside	1,340	259	6	Do	Catskill	24	109±	6	do	Small draw-down pumping 6 gal- lons a minute for 10 hours.
277	1½ miles north- east of Kunkle	Col. D. Rey- nolds	Hilltop	1,540	504	6	Gray, red, and brown sandstone	do	-----	200±	8	do	Small draw-down pumping 8 gal- lons a minute for 24 hours.
278	1½ miles north of Dallas	Dallas Water Co.	Hillside	1,300	188	6	Red and gray sand- stone	do	10-12	70±	50	P S	Small draw-down pumping 50 gallons a minute for consider- able period; see analysis 278; Temperature 63° F., Sept. 16, 1930.
279	1½ miles north- west of Dallas	do	Valley	1,240	153	6	do	do	16	30	60	do	Reported that well flowed several years prior to 1930; small drawdown pumping 60 gallons a minute for a considerable period.
280	0.3 miles south of Dallas	do	Hilltop	1,280	305	6	-----	do	-----	100±	12	do	Well is pumped at 12 gallons a minute all day.
281	Shavertown	Mr. Fernbrook	Valley	1,000	128	6	-----	do	27	Flows	30	D	Flows 30 gallons a minute.
282	do.	Wm. Still	Hillside	1,080	244	6	-----	do	18	40	18	do	Draw-down 35 feet pumping 18 gallons a minute; draw-down is reached in a very short time, but the water level remains at this point after prolonged pumping.
283	¾ mile north- east of Shaver- town	Shavertown Water Co.	do	1,180	364	6	-----	do	-----	-----	10	P S	
284	1½ miles east of Dallas	Dallas Water Co.	Hilltop	1,320	580	6	-----	do	-----	-----	12	do	
	Franklin Twp.												
285	0.6 mile west of Orange	Con McCoe	Near hilltop	1,260	300	6	Sandstone	do	10	40	7+	D	Draw-down 20-25 feet pumping 7+ gallons a minute; some water encountered at a depth of 60 feet.
286	½ mile south- west of Orange	Mr. Goring	Hillside	1,180	200	6	-----	do	15	60	20	do	Small draw-down pumping 20 gallons a minute.
287	0.2 mile south of Orange	W. Meck	do	1,200	225	-----	Red sand- stone	do	-----	60	20	do	Draw-down 50 feet pumping 20 gallons a minute.
288	1.9 miles south east of Orange	Mount Zion Church	Canyon	1,240	160	6	Gray sand- stone	do	10	20	6	do	Draw-down 50 feet pumping 6 gallons a minute.

Drilled wells in Luzerne County—Continued

No.	Location ¹	Owner or tenant	Topographic situation	Altitude ² (feet)	Depth (feet)	Diameter (inches)	Character of water-bearing material	Geologic horizon	Length of casing (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
289	Exeter Twp. 2.1 miles east of Orange	Lawrence Swartwood	Canyon	780	142	6	Gray sandstone	Catskill	25	20±	10	D	Small draw-down pumping 10 gallons a minute; some water at depth of 140 feet.
290	2.3 miles east of Orange	John Berlew	do	780	130	6	do	do	2	50	3	do	
291	0.4 mile southwest of Ransom	Mr. Osgrove	Hillside	680	74	6	Green sandstone	do	57	11-13	-----	do	Adequate supply; bedrock overlain by 57 feet of drift.
292	1½ miles north of Harding	-----	Edge of valley	580	63	6	do	do	54	Flows	Small	do	
293	do.	Stanton estate	Hillside	600	211	10-6	Blue sandstone	do	140	111±	6	do	Small draw-down pumping 6 gallons a minute; bedrock overlain by 104 feet of sand and gravel containing considerable water.
294	do.	Stanton Operating Co.	River terrace	4 557.8	96±	24	Gravel	Glacial outwash	96±	31.84	1,000	C	3 drilled wells finished with screens in sand and gravel; for details of screens see p. 35 (fig. 5) minimum temperature 51° F. (January and February); maximum temperature 55° F. See log.
295	do.	do	do	4 557	69½	10	do	do	69½	30±	200	D	Finished with a screen in sand and gravel, see log.
296	2½ miles northwest of West Pittston	Wyoming Camp Ground	High saddle	1,420	250-275	6	Red and gray sandstone	Catskill	80	75?	6-7	do	
297	Kingston Twp. 3.6 miles northeast of Wyoming	Mr. Corsons	Upland	1,200	100	6	Gray sandstone	do	68	Flows	Small	do	Flows a few gallons a minute. Well began to flow at a depth of 90 feet; bedrock overlain by 68 feet of glacial drift; gray sandstone underlain by blue slate.

298	2.1 miles north-east of Trucks-ville	Methodist Episcopal Parsonage	Hillside	1,280	93	6	Sandstone	do	34	Flows	Large	do	Water level stands 20± feet above the ground surface.
299	0.9 mile north of Trucks-ville	Stegmans Farms	do	1,020	95	6	Red shale	do	20	Flows	4-5	do	Flows 4 or 5 gallons a minute; would yield considerably more by pumping.
300	Shavertown	Shavertown Water Co.	do	1,050	171	6	-----	do	-----	-----	15	P S	
301	do.	do	do	1,060	205	6	-----	do	-----	-----	18	do	See analysis 301; temp. 52°F., Sept. 15, 1930.
302	0.6 mile north of Trucks-ville	C. D. Hazeltine	do	1,040	285	6	-----	do	-----	-----	6-	do	Pumps dry at 6 to 8 gallons a minute.
303	0.4 miles north-west of Trucks-ville	Harold Rust	do	1,020	400	-----	-----	do	-----	12-15	14	do	Draw-down 160 feet pumping 14 gallons a minute.
304	0.6 mile east of Trucks-ville Plymouth Twp.	C. D. Hazeltine	do	1,180	505	6	-----	do	18	80	8	do	Draw-down 200 feet pumping 8 gallons a minute for several hours.
305	2 miles north of Plymouth	Seranton Spring Brook Water Co.	do	840	1,000±	-----	-----	Pottsville?	-----	-----	-----	do	
306	do.	Al Gregory	Near top of ridge	1,000-1,200	350	6	Conglom- erate	Pocono(?)	-----	Fluc- tuates	-----	D	
307	do.	do	do	1,000-1,200	200	6	Red shale	Catskill	20	Flows	Small	do	
308	do.	Ed. Price	do	1,400	60	6	White and gray sand- stone	do	-----	do	do	do	Flows a few gallons a minute except during exceptionally dry summers.
309	1½ miles west of Plymouth	Seranton Spring Brook Water Co.	Hillside	760	1,950	-----	-----	Pottsville	-----	do	Large	P S	
310	do.	do	do	820	1,040	-----	-----	do	-----	do	do	do	
311	½ mile south-east of West Nanticoke	J. W. Ratchford	River terrace	520	175	-----	Gray sand- stone	do	60	do	10±	B	Flows more than 10 gallons a minute.
312	West Nanticoke	James Medly	do	520	154	6	Conglom- erate	Pocono	106	do	12	D	Water level stands 22± feet above the ground surface; 106 feet of outwash gravel; conglomerate overlain by gray shale.
313	do	do	Hillside	580	98	4-2	Conglom- erate	Pocono	46	do	7.23	B	Flow measured September 16, 1930 and 1931 without change; water level stands 6 feet above ground surface; see analysis 313; diamond-drill hole; this well will not flow continuously unless well 312 is capped; temperature 52°F., Sept. 16, 1930.

Drilled wells in Luzerne County—Continued

No.	Location ¹	Owner or tenant	Topographic situation	Altitude ² (feet)	Depth (feet)	Diameter (inches)	Character of water-bearing material	Geologic horizon	Length of casing (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
314	$\frac{1}{2}$ mile southwest of West Nanticoke	Charles Rowe	Hillside	660	355	6	Red and blue sandstone	Pocono	20	80	3	D	Pumps dry when pumping more than 3 gallons a minute.
315	1.4 miles southwest of West Nanticoke	A. Swithers	River terrace	520	30	1 $\frac{1}{2}$	"Quicksand"	Glacial outwash	30	6	-----	do	Driven well; "quicksand" enters the pipe producing turbid water; loam 20 feet, gray clay 4 feet, "quicksand" 6 feet.
316	1 $\frac{1}{2}$ miles southwest of West Nanticoke Jackson Twp.	Mr. Sable	do	520	52	1 $\frac{1}{2}$	Gravel and sand	do	25-32	39	-----	do	Dug 25 feet, driven 27 feet; clay 13 feet; gravel 12 feet, sand and gravel 27 feet; satisfactory supply.
317	1 $\frac{1}{2}$ miles east of Cease Mills	B. G. Laskowski	Hillside	1,000	119	6	-----	Catskill	14?	20	-----	do	
318	1 $\frac{1}{2}$ miles southwest of Chase	W. Beline	do	1,100	185	6	Red and gray sandstone	do	14	6	8	do	Draw-down 60 feet pumping 8 gallons a minute for 5 hours.
319	do.	Ira Johnson	Valley	1,080	320	6	Hard red and gray sandstone	do	14	25	6	do	Draw-down 25 \pm feet pumping 6 gallons a minute for $\frac{1}{2}$ day.
320	do.	Mr. Prutzman	do	1,080	51	6	Gray sandstone	do	12	6	10	do	Small draw-down pumping 10 gallons a minute for 2 hours.
321	do.	Ira Van Orton	do	1,080	36	6	do	do	-----	8	10	do	Do
322	$\frac{1}{2}$ mile northwest of Chase	J. J. Becker	do	1,060	300	6	Gray sandstone; some red	do	22	60	60	do	
323	0.4 mile southeast of Huntsville	R. Prutzman	Hillside	1,120	265	6	do	do	Shallow	50	-----	do	
324	Huntsville	Mrs. J. Rogers	Valley	1,140	147	10-6	-----	do	10	19	3	do	Pumps dry pumping 4.6 gallons a minute for 14 minutes.

	Lehman Twp.												
325	0.8 mile north- west of Huntsville	E. B. Mulligan, Jr.	Hilltop	1,300	254	6	Red and gray sand- stone	do	3	150	50	do	Small draw-down pumping 50 gallons a minute continuously.
326	0.9 miles south- east of Ide- town	Lake Improve- ment Co.	Hillside	1,220	260	8	Gray sand- stone	do	147½	60	18+	do	Draw-down 100 feet pumping 18+ gallons a minute; bedrock over- lain by about 147 feet of sand, gravel, and blue clay.
327	do.	Mr. Yarrington	do	1,240	115	-----	-----	do	33	20	12	do	Large draw-down pumping 12 gallons a minute; bedrock over- lain by 33 feet of blue clay; well is 300 feet north of well 326.
328	Lake	Lake Improve- ment Co.	Lakeside	1,240	212	6	-----	do	115	-----	25	do	Well usually flows, with the water level 2 feet above the surface; on August 28, 1930, the water level was below the surface; bedrock overlain by 115 feet of quicksand and boulders; draw-down 40 feet pumping 25 gallons a minute.
329	Lehman	G. Johnson	Upland	1,308	107	6	-----	do	20	40±	15	do	Moderate draw-down pumping 15 gallons a minute.
330	½ mile north- west of Silk- worth	Wyoming Valley Realty Co.	Hilltop	1,280	700	6	Red and gray sand- stone	Portage(?)	Shallow	300	6	do	Pumps dry pumping 6 gallons a minute for 1½ hours.
	Hunlock Twp.												
331	½ mile south of Prichard	Weitzel M. E. Church	Ridge	1,180	60	6	Gray sand- stone	Catskill	20	20	8	do	
332	2¼ miles east of Muhlenberg	Baptist Church	Hillside	980	80-90	6	Sand and gravel	Glacial drift	80-90	50-60	10	do	Well does not reach bedrock.
333	1 mile north- west of Hun- lock Creek	Mr. Kiesel	Valley	680	50	6	do	do	50	10	10	do	Small draw-down pumping 10 gallons a minute; well does not reach bedrock.
334	Hunlock Creek	S. Croup	do	540	375	6	Gray sand- stone	Pocono	65	14	6	do	Draw-down 8 feet pumping 6 gallons a minute for 1 hour in 1930; in 1910 reported draw- down 13 feet pumping 8 gal- lons a minute for 15-20 hours; see analysis 334; see log; temp- erature 52°F., Sept. 16, 1930.
335	0.2 mile south- west of Hun- lock Creek	Luzerne County Gas & Elec- tric Co.	River terrace	520	253	8	Gray and red sand- stone	do	Shallow	50	18±	do	Draw-down 25 feet pumping 18± gallons a minute indefinitely; bedrock is at the surface, but a well drilled nearby was abandoned at a depth of 91 feet in "quicksand".

Drilled wells in Luzerne County—Continued

No.	Location ¹	Owner or tenant	Topographic situation	Altitude ² (feet)	Depth (feet)	Diameter (inches)	Character of water-bearing material	Geologic horizon	Length of casing (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
336	1.3 miles southwest of Hunlock Creek Union Twp.	Central poor district	Near hilltop	1,240±	557	6	Hard gray sandstone	Pocono	5-6	Flows	3	D	Flows 3 gallons a minute but would yield considerably more by pumping.
337	$\frac{3}{4}$ mile west of Retreat	Retreat Dairy Farm	Hillside	620	-----	10	-----	do	-----	-----	20	do	Also uses spring supply.
338	$\frac{1}{4}$ mile northwest of Muhlenberg	Mike Polander	do	1,080	115	6	Gray sandstone	Portage	21	63	Very small	do	Well unfinished; yield at the time record was taken was only 2 gallons an hour.
339	$\frac{1}{2}$ mile northwest of Shick-shinny	Jake Balshamer	Canyon	650±	47	6	Sand and gravel	Glacial drift	47	7	-----	do	Well does not reach bedrock.
340	$\frac{1}{2}$ miles northwest of Shick-shinny Huntington Twp.	Mr. Carey	Hillside	660	63	6	Soft gray rock	Catskill	20	30±	-----	do	
341	$\frac{1}{2}$ mile east of Huntington Mills	J. Lord	Upland	980	140	6	Black slate and gray sandstone	Portage	25	30	10	do	Small draw-down pumping 10 gallons a minute.
342	Huntington Mills	Woodlawn Dairy Co.	Valley	800	249	8	do	do	60	Flows	12	I	Draw-down 40± feet pumping 12 gallons a minute for 3 or 4 hours; flows a few gallons a minute; water contains hydrogen sulphide, see analysis 342, bedrock overlain by 60 feet of sand, gravel, clay and "quick-sand"; temperature, 53°F., Sept. 16, 1930.
343	Cambra	H. C. Hagenbaugh	Hilltop	1,080	86	6	Blue "slate"	do	34	46	2	D	When well is pumped dry, it refills at the rate of 2½ gallons a minute.

344	1.8 miles east of New Columbus Salem Twp.	Dr. Van Horn	Upland	940	200	6		do				do	
345	1 $\frac{3}{4}$ miles south Shickshinny	Mr. Cisco	Valley	540	145	6	Dark-gray sandstone	Catskill	140	25	25	do	Small draw-down pumping 25 gallons a minute; bedrock overlain by 140 feet of gravel and "quicksand" with cobbles at the top; some water in the drift at 40 feet.
346	3 $\frac{1}{4}$ miles south Shickshinny	Emil Siesko	do	520	148±	-----	Gravel (?)	Glacial drift	148±	48-	-----	do	Well penetrates 147± feet of "quic sand" and gravel and is drilled 1 foot into bedrock; small draw-down pumping for half a day.
347	$\frac{1}{2}$ mile north-west of Hicks Ferry	Mingle Inn	Hillside	580	150	6	Blue "slate"	Marcellus	50	-----	-----	do	Bedrock overlain by 50 feet of "quicksand" and gravel.
348	1 $\frac{1}{2}$ miles east of Beach Haven	M. J. Markovich	High terrace	620	100	6	Dark "slate"	do	75?	30	-----	do	Water contains considerable iron and hydrogen sulphide.
349	Beach Haven Slocum Twp.	B. S. Davis	do	540	102	6	Black "slate"	do	15±	14	9	do	Moderate draw-down pumping 9 gallons a minute all day; bedrock overlain by 15 feet of boulders.
350	Slocum Newport Twp.	Evan Evans	Hillside	1,160	110	6	Gray sandstone	Catskill	20	40	8	do	
351	Retreat	Retreat County Poor Farm	do	700	807	6	do	Pocono(?)	4	30	65	do	Hard red sandstone 400 feet, gray sandstone 407 feet.
352	do.	Retreat Mental Hospital	River terrace	523	800±	12	Hard conglomerate	do	100±	300±	133	H	Draw-down 40± feet pumping 133 gallons a minute for about 2 hours; bedrock overlain by 100 feet of glacial outwash.
353	do.	do	do	520	60	12	Outwash gravel	Glacial drift	60	30±	525	do	Draw-down 8 feet pumping 525 gallons a minute for 24 hours; well finished in gravel with a Cook screen containing 1/32-inch slots; water occurs in gravel lying on blue clay and overlain by sand and gravel.
354	$\frac{3}{4}$ mile south-east of Alden	East Alden Coal Co.	Hillside	1,120	420	6	Hard red sandstone and shale	Mauch Chunk	12	6	6	D	Draw-down 20± feet pumping 6 gallons a minute

Drilled wells in Luzerne County—Continued

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GROUND WATER

No.	Location ¹	Owner or tenant	Topographic situation	Altitude ² (feet)	Depth (feet)	Diameter (inches)	Character of water-bearing material	Geologic horizon	Length of casing (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
355	Hanover Twp. $\frac{1}{2}$ mile southeast of Sugar Notch	Seranton Spring Brook Water Co.	Canyon	1,000	550	8	-----	Pottsville	-----	Flows	Large	P S	
356	1 mile southeast of Moffat Patch Wilkes-Barre and Laurel Run Twp.	do	do	960	550	-----	-----	Mauch Chunk	-----	do	-----	do	
357	Wilkes-Barre	Frank Martz	River terrace	520	180	6	Gray sandstone	Post-Pottsville	150	6	50	D	Small draw-down pumping 50 gallons a minute for 1 week. Sand and gravel 35 feet, "quick-sand" 115 feet, gray sandstone 30 feet, water encountered in gray sandstone at 170 feet; only about 2 gallons a minute above 170 feet.
358	do.	Horn Dairy	do	520	45	1 $\frac{1}{2}$	Sand	Glacial drift	45	17	-----	I	Small draw-down pumping all day; driven well into sand; see analysis 358; temperature 56°F. Sept. 16, 1930.
359	do.	Meyers High School	do	520	210	6	Gray sandstone	Post-Pottsville	100	-----	2	N	Test well 1; produced 2 gallons a minute from the sandstone at 100 feet.
360	do.	do	do	520	115	6	do	do	100	-----	0	do	Test well 2; dry hole.
361	do.	do	do	520	240	6	do	do	120	25	10	D	Test well 3; this well now used; at a depth of 120 feet coal wash produced 60 gallons a minute and the water rose to the surface; water was dirty at first but soon cleared up and was potable; water contains hydrogen sulphide.

362	$\frac{1}{2}$ mile south of Georgetown	Seranton Spring Brook Water Co.	Hillside	1,160		8		Pottsville		Flows	24	P S	Diamond-drill hole drilled into the side of the mountain at an angle of 45°; flows 24 gallons a minute.
363	0.9 mile east of Oliver Mills Plains Twp.	Sunset Inn	do	1,720	80	6	Yellow sandstone	Catskill	2	50	10	D	Large draw-down pumping 10 gallons a minute.
364	2.4 miles north of Oliver Mills	G. Thomas	do	1,340	142	6-4		do	13	28	Large	do	
365	do. Pittston Twp.	do	do	1,320	94		Red shale	do	13	40	do	do	Boulders and sand 13 feet, gray sandstone 42 feet, conglomerate 10 feet, red shale (water-bearing) 29 feet.
366	$2\frac{1}{2}$ miles south-east of Moosic Bear Creek Twp.	Mr. Glenburn	Canyon	880	725	10	Quartz conglomerate	Pocono	0	200	do	do	Small draw-down; coal struck at depth of 40 feet.
367	$5\frac{1}{2}$ miles north-east of Bear Creek Bucks Twp.	Mr. Chase	Upland	1,991	104	6	Red and green sandstone	Catskill	45	22		do	
368	Indian Lake	J. Newhart	Hillside	1,900	783	6		do	16	28		do	
369	Stoddardsville Fairview Twp.		do	1,500	174		Hard sandstone	do	Shallow	70	2	do	
370	0.4 mile south-east of Mountaintop	John Girecheck	do	1,620	125	6	Red sandstone	do		40	11	do	Pumps dry pumping more than 11 gallons a minute.
371	0.3 mile north-east of Glen Summit	F. M. Kirbi	Hilltop	1,920	565	8	Sandstone	do	Shallow	215	20	do	Drilled with a diamond drill between depths of 350 and 565 feet; water level measured in 1927; at a depth of 450 feet the drill dropped 2 feet and the water rose rapidly; above this point the well could be pumped dry in 20 minutes; well now yields 20 gallons a minute all day.
372	0.2 mile south west of Glen Summit	P. Berkeiser	Hillside	1,600	120	6	Gravel	Glacial drift	120	30	8	do	Small draw-down pumping more than 8 gallons a minute; well does not reach bedrock.

Drilled wells in Luzerne County—Continued

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No.	Location ¹	Owner or tenant	Topographic situation	Altitude ² (feet)	Depth (feet)	Diameter (inches)	Character of water-bearing material	Geologic horizon	Length of casing (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
373	Wright Twp. 1½ miles south- west of Mountaintop	-----	Upland	1,400	52	6	-----	Catskill	-----	-----	6	D	
374	1½ miles south- west of Mountaintop	Mr. Milroy	do	1,420	65	6	-----	do	36	28	20	do	Small draw-down pumping 20 gallons a minute; water en- countered at a depth of 38 feet.
375	1.1 miles east of Albert	Tessie Johns	Hillside	1,340	90	6	Clay	Glacial drift	90	20	10	do	Small draw-down pumping more than 10 gallons a minute; well does not reach bedrock.
376	Albert	Mr. Bronson	do	1,240	76½	-----	Hard red sandstone	Catskill	4	20	11	do	At a depth of 74 feet 10 inches the well yielded only 1.6 gal- lons a minute.
377	1.2 miles south- west of Albert	Mr. Knies	do	1,160	60	6	Red shale	Portage(?)	-----	18	-----	do	
378	Blytheburn	Mr. Evans	Valley	1,140	150	6	do	do	80	6	1	do	Large draw-down pumping 1 gal- lon a minute.
379	2 miles south- east of Nuengola	George Rumpelli	Hillside	1,160	60	6	Gray sand- stone	do	-----	Flows	3-4	do	Flows 3 or 4 gallons a minute.
380	Nuengola	Mr. Miller	Hilltop	1,260	110	6	Red sand- stone	Catskill	Shallow	40	11	do	Pumps dry rapidly pumping 11 gallons a minute.
381	do.	Martin Wam- boldt	do	1,340	126	6	do	do	2	40	11	do	Do
	Dorrance Twp.												
382	1 mile south- east of Dor- rance	Charles Fey	Valley	1,000	89	6	Shale	Portage	21	22	Very weak	do	Pumps dry.
383	Dorrance	Herbert Huff- man	Hilltop	1,160	60	6	Gray shale	do	5	30	1	do	Pumps dry rapidly pumping 1 gallon a minute.
384	do.	Mr. Winter- grass	Hillside	1,120	75	6	Shale	do	7-8	30	3.3	do	Small draw-down pumping 3.3 gallons a minute.

GROUND WATER

	Hollenback Twp.												
385	0.6 mile north-east of Hobbie	A. Hock	Valley	980	110	6	-----	do	-----	-----	8	do	Draw-down 35 feet pumping 12 gallons a minute for 20 to 25 minutes. Dug well; depth to water level measured Nov. 7, 1931; see pl. 4.
386		Mr. Weiss	Hillside	1,000	75	6	-----	do	-----	25	12	do	
387	2½ miles south-east of Wap-walopen	C. P. Readler	do	810	25.6	24	Sand and gravel	Glacial drift	25.6	27.1	-----	N	
388	1.4 miles north-east of Wap-walopen	A. Gröber	High ridge	1,040	142	6	Gray sand-stone	Hamilton	45	60-70	7	D	
	Nescopeck Twp.												
389	1.6 miles north-west of Briggs-ville	Mr. Slosser	Upland	960	138	6	-----	Portage	-----	38±	-----	do	
390	0.6 mile south-west of Empire	G. Yoder	Hillside	800	96	6	Gray sand-stone	Catskill	15	-----	6	do	
	Black Creek Twp.												
391	Mountain Grove	George Webster	Slope	1,020	94	6	Sand and gravel	Glacial outwash	94	10	10±	do	Small draw-down pumping more than 10 gallons a minute.
392	Nuremberg	A. W. Brooks	Hillside	1,200	438	6	Sandstone	Pottsville	16	80	33	do	
393	do	Mr. Kemersal	do	1,080	65	6	Light sand-stone	do	40	38	25	do	
394	½ mile north-west of Der-ringer	Wyoming Valley Water Co.	do	1,230	689	8	Green sand-stone	do	25½	10-44	35	P S	Small draw-down pumping 35 gallons a minute day and night; see analysis 394, see log temperature 56°F., Sept. 15, 1930. Bedrock overlain by 60 feet of sand and gravel containing some water.
395	Weston	-----	Valley	1,120	70	6	Red shale	Mauch Chunk	60	15	25	D	
396	do	Mr. Enamel	do	1,140	110	6	Red sand-stone	do	20	50	10	do	
	Sugar Loaf Twp.												
397	1½ miles south-east of Conyngham	J. Davis	Ridge	1,520	150	6	Light sand-stone	Pottsville	6	60	20	do	Small draw-down pumping 20 gallons a minute.

Drilled wells in Luzerne County—Continued

No.	Location ¹	Owner or tenant	Topographic situation	Altitude ² (feet)	Depth (feet)	Diameter (inches)	Character of water-bearing material	Geologic horizon	Length of casing (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
398	1½ miles south-east of Conyngham	Robert Jones	Hillside	1,560	80	6	Gray sandstone	Pottsville	14	24	50	D	Draw-down less than 2 feet pumping 50 gallons a minute for 25 minutes.
399	1½ miles south-east of Conyngham	Henri Twins	do	1,460	200	-----	Red and gray shale	Mauch Chunk	20	175	small	do	
400	Conyngham	Mr. Hess	do	1,100	90	6	Red sandstone	do	30	40	large	do	
401	do	Guy Hutton	do	1,040	266	8	-----	do	-----	80	33	P S	Auxiliary to spring supply; see analysis 401; temperature 51°F. Sept. 15, 1930.
402	¾ mile north-east of Conyngham	-----	do	1,020	100	6	Red sandstone	do	32	35	15-20	D	
403	1.1 miles west of Sybertsville	A. Orinsky	do	1,000	220	6	Red shale	do	4	80	1+	do	
404	Sybertsville	B. C. Wills	Valley	900	67	6	Red sandstone	do	30	35	8	do	
405	¾ mile north-east of Sybertsville	T. P. Pardee	do	900	268	6	do	do	38	45	10	do	
406	1½ miles north of Sybertsville	-----	Hillside	940	201	6	Red sandstone	do	14	30	small	do	Pumps dry in a short time.
407	1½ miles north of Sybertsville	-----	do	1,120	110	6	-----	do	50±	40	5	do	Bedrock overlain by about 50 feet of sand and gravel.
408	2 miles north-east of Sybertsville	Adams Oaks	do	1,960	92	6	-----	do	30	40	10	do	Moderate draw-down pumping 10 gallons a minute.
	Butler Twp.												
409	Saint Johns	Mr. Comfort	Valley	1,020	50	6	Sand and gravel	Glacial drift	50	20	large	do	Small draw-down; well does not reach bedrock.
410	¾ mile south-east of Drums	Mr. Yound	Hillside	1,100	51	6	-----	Mauch Chunk	22	-----	-----	do	Adequate supply.

411	2½ miles north-east of Drums	Dinkblacker & Balander	Hillside	1,100	92	6	Hard red-sandstone	do	11	25-30	11½	do	Draw-down 25 feet pumping 11½ gallons a minute for 15 to 20 minutes, after which the water level remains nearly constant.
412	2½ miles north-east of Drums	Hooks Garage	Valley	1,060	100	6	-----	do	-----	20	8	do	Small draw-down pumping 8 gallons a minute.
413	2¾ miles north-east of Drums	Butler Township School	do	1,080	157	6	Sand with some gravel	Glacial drift	157	30	15	do	Well does not reach bedrock; some water encountered at a depth of 50 feet.
414	2¾ miles north-east of Drums	Mr. Hoak	do	1,080	65	6	Red shale	Mauch Chunk	13	30	5	do	
415	¾ mile north-west of Drifton	Wyoming Valley Water Co.	Canyon	1,820	600	10-8	-----	do	60	0-100±	100-200	P S	Well flows in wet seasons; water level drops to 100± feet below the surface in the summer; moderate draw-down pumping 100 gallons a minute 24 hours a day; bedrock overlain by 60 feet of clay; see analysis, 415; temperature 49°F., Sept. 15, 1930.
Dennison Twp.													
416	1¼ miles north-west of White Haven	P. J. Murphy	Ridge	1,360	120	6	Hard red sandstone	Mauch Chunk	15	60	25	D	
Foster Twp.													
417	¾ mile north-west of White Haven	James Larson	Hillside	1,300	38	6	do	do	15	15±	15	do	Small draw-down pumping 15 gallons a minute.
418	½ mile south-west of White Haven	White Haven Sanitorium	Valley	1,200	345	10	Gray sandstone	do	35	90	30	H	Moderate draw-down pumping 30 gallons a minute; "Hardpan" 35 feet, red shale 265 feet, gray sandstone 45 feet.
419	½ mile south-west of White Haven	do	Hillside	1,400	520	6	-----	do	-----	-----	15	do	
420	¾ mile south-west of White Haven	do	do	1,460	1,000	6	-----	do	-----	-----	12	do	Well yielded 80 gallons a minute at a depth of 500 feet, but the water was lost at greater depth, and efforts to plug the well failed.
421	1 mile south-west of White Haven	Comer Gas Station	do	1,360	100	6	Red sandstone	do	40	65	5	D	Bedrock overlain by 40 feet of sand and pebbles.
422	2 miles south of White Haven	Mrs. Miller	do	1,340	65	6	Red shale and sandstone	do	20	25-30	5	do	Small draw-down pumping 5 gallons a minute.

Drilled wells in Luzerne County—Continued

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No.	Location ¹	Owner or tenant	Topographic situation	Altitude ² (feet)	Depth (feet)	Diameter (inches)	Character of water-bearing material	Geologic horizon	Length of casing (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
423	2 miles south of White Haven	Mr. Trotsky	Hillside	1,380	150	-----	Red sandstone	Mauch Chunk	20	20	25	D	Dug 30 feet, drilled to 300 feet; some water at 40 feet; small draw-down pumping 25 gallons a minute.
424	1½ miles west of White Haven	White Haven Water Co.	do	1,320	700-800	10	do	do	20	Shallow	-----	P S	
425	1½ miles east of Sandy Run	Mr. Bronchmeyer	do	1,400	64	6	Red shale	do	43	40±	-----	D	
426	¾ mile northwest of Sandy Run	Jeddo Highland Coal Co.	do	1,740	699.5	8	Red sandstone	Pottsville	10	50±	60	P S	See log.
427	¾ mile southwest of Zehner	Walt Fairchild	Upland valley	1,660	155	6	Gray sandstone	do	20	20	63	S P	Water level drops nearly to the bottom pumping 63 gallons a minute for 24 hours a day; another well 200 yards away is 300 feet deep, depth to water 19 feet, small draw-down pumping 67 gallons a minute, moderate draw-down pumping 83 gallons a minute; coal stripping 200 yards away extends to a depth of 400 feet.
428	1 mile southwest of Zehner	Jeddo Highland Coal Co.	do	1,640	150	8	Green sandstone and shale	do	22	40±	40-75	I	Pumps 40 gallons a minute during dry season and 75 gallons a minute during wet seasons; surface material 22 feet, red sandstone 20 feet, green sandstone and shale 108 feet.
429	½ mile east of Upper Lehigh	Freeland Water Co.	Hillside	1,760	700±	6	-----	Mauch Chunk (?)	40	Flows	90	P S	Well flows 60 gallons a minute during wet seasons; during dry seasons the water level drops to 220 feet below the surface and the well yields 90 gallons a minute with small draw-down.

GROUND WATER

430	$\frac{1}{4}$ mile east of Upper Lehigh	do	do	1,800	150	6	Hard white sandstone	Pottsville	40	do	30-40	do	Well flows 30 to 40 gallons a minute during wet seasons; water level drops to 120 feet below the surface in dry seasons.
431	Upper Lehigh	do	do	1,800	700 \pm	6	-----	Mauch Chunk (?)	40	do	90	do	Well flows 60 gallons a minute during wet seasons; during dry seasons the water level drops to 220 feet below the surface and the well yields 90 gallons a minute with small draw-down.
432	South Heberton	do	do	1,760	325	10	Red sandstone	Mauch Chunk	169	18- 160	10	do	Well 2; depth to water level 18 feet in wet seasons, 160 feet in dry seasons; bedrock overlain by 40 feet of loam and "quicksand"; well formerly flowed 60 gallons a minute; casing then extended from 40 to 169 feet owing to suspected pollution and water level dropped to 18 feet below the surface.
433	do	do	do	1,760	275	10	do	do	40	Flows	180 \pm	do	Well 5; 65 feet from well 2; flows 120 gallons a minute in wet seasons; water level drops to 40 feet below the surface in dry seasons; draw-down 160 feet pumping 180 \pm gallons a minute for 3 or 4 minutes during dry seasons.
434	Freeland	do	do	1,890	225	8	Gray sandstone	Pottsville (?)	44	do	90- 250	do	Well 1; flows a small amount in wet seasons, depth to water 24 feet in dry seasons; during wet seasons draw-down 10 feet pumping 250 gallons a minute; during dry seasons draw-down 133 feet pumping 150 gallons a minute; after 3 hours pumping the yield is reduced to 90 gallons a minute.
435	do	do	do	1,860	287 $\frac{1}{2}$	12	-----	do	34	do	50-150	do	Well 3; flows a small amount in wet season; depth to water 24 feet in dry seasons; draw-down 109 feet pumping 150 gallons a minute for 15 to 20 minutes; after 3 hours pumping the yield is reduced to 50 gallons a minute; see analysis 435; temperature 53°F. Sept. 15, 1930.

Drilled wells in Luzerne County—Continued

No.	Location ¹	Owner or tenant	Topographic situation	Altitude ² (feet)	Depth (feet)	Diameter (inches)	Character of water-bearing material	Geologic horizon	Length of casing (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
436	Freeland	Freeland Water Co.	Hillside	1,860	500	8	-----	Mauch Chunk (?)	24	Flows	150	P S	Well 7; flows during wet seasons; depth to water 90 feet during dry seasons; draw-down 100± feet pumping 400 gallons a minute; after 3 hours pumping the yield is reduced to 150 gallons a minute.
437	do	do	do	1,860	525	10	-----	do	35	do	65-150	do	Well 4; flows during wet seasons; depth to water 50 feet during dry seasons; draw-down 250 feet pumping 150 gallons a minute; after 3 hours pumping yield is reduced to 65 gallons a minute.
438	do	do	do	1,860	425	-----	-----	do	-----	Below surface	8	do	Maximum yield 8 gallons a minute; yet this well is located among a group of strong wells.
439	$\frac{1}{2}$ mile south-east of Freeland	Jeddo Highland Coal Co.	do	1,800	500 $\frac{1}{2}$	8	Red and green sandstone	do	33	Flows	5+	-----	Flows 5+ gallons a minute; pumps dry rapidly at a small pumping rate; see log.
440	$\frac{1}{2}$ mile north of Drifton	Wyoming Valley Water Co.	do	1,780	554	10-8	do	do	-----	100±	100	P S	Draw-down 126 $\frac{1}{2}$ feet pumping 100 gallons a minute in May, 1914. See log.
441	$\frac{3}{4}$ mile west of Eckley	do	do	1,560	500	10	Red and blue sandstone	do	12	Flows	100	do	Flows more than 100 gallons a minute in the winter; depth to water 75 feet in the summer; yields 100 gallons a minute by pumping; reported that prior to 1929 the well flowed 12 months a year.
442	1 $\frac{1}{2}$ miles north-east of Jeddo	Jeddo Highland Coal Co.	do	1,640	600	8	-----	do	-----	Below surface	small	do	Water level very low during summer of 1930.

443	do	do	do	1,660	364	-----		do	-----	Flows	50	do	Flows 25 gallons a minute during wet seasons; depth to water in dry seasons 75± feet; well is pumped at the rate of 50 gallons a minute during the summer.
444	do	do	do	1,640	1,000	-----	Red sand-stone	do	16	300-400±	20	do	See log.
445	¾ mile south-east of Jeddo	do	do	1,560	371	4	Red and green sand-stone	do	53	75±	80-125	do	Well pumped 365 days a year.
446	do	do	do	1,560	596	-----	do	do	140	Below surface	20	do	See log; drilled down a vertical fault plane for 140 feet, which required casing.
	Hazel Twp.												
447	1 mile south-west of Jeddo	do	Edge of valley	1,500	634	6	do	Mauch Chunk or Pottsville	-----	80-90	100	do	See log.
448	do	do	do	1,500	744½	8	do	do	13	120±	20±	do	
449	1¼ miles south-west of Jeddo	do	do	1,500	1,557	10-6	do	Mauch Chunk	16	100±	35	do	
450	Ebervale	do	Hillside	1,600	450	10-8	Green sand-stone and conglomerate	Pottsville	11	150±	150	do	See log.
451	do	do	do	1,580	171	10-8	do	do	14±	Flows	50	do	Flows during wet seasons; depth to water 30± feet during dry seasons; yields 50 gallons a minute by pumping; see analysis 451; log similar to that of well 450 except that there is no coal; temperature 51° F. Sept. 15, 1930.
	Butler Twp.												
452	¾ mile east of Lattimer	Pardee Bros. Coal Co.	Slope	1,640	332	11	-----	do (?)	-----	220±	8½	do	Three-stage air lift; first stage 140 feet, second 220 feet, third 301 feet; first stage can be used only in wet seasons; on Sept. 12, 1930, the third stage was being used.
	Hazel Twp.												
453	¾ mile east of Lattimer	do	do	1,620	290	6	-----	do (?)	-----	190±	10	do	Three-stage air lift; first stage 124 feet, second 190 feet, third 278 feet; first stage can be used only in wet seasons; on Sept. 12, 1930, the third stage was being used.

Drilled wells in Luzerne County—Continued

No.	Location ¹	Owner or tenant	Topographic situation	Altitude ² (feet)	Depth (feet)	Diameter (inches)	Character of water-bearing material	Geologic horizon	Length of casing (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
454	Lattimer and Milnesville	Pardee Bros. Coal Co.	-----	-----	150±	-----	-----	Pottsville	-----	-----	10	P S	Average depth and yield for 7 drilled wells between Lattimer and Milnesville; all yield about 10 gallons a minute by air lift; the water level in all the wells was exceptionally low on Sept. 12, 1930.
455	Harleigh	Jeddo Highland Coal Co.	Edge of valley	1,500	895	10	Red, gray, and green sandstone, fine con- glomerate	Pottsville or Mauch Chunk	10	50±	10	do	Well not used at present because the yield is too small; see log.
456	1 mile south- west of Eber- vale	do	Hillside	1,700	566½	10-8	Red and green sand- stone	do	24	-----	160±	do	Draw-down 115 feet pumping 160± gallons a minute for 43 hours; see log.
457	do	do	do	1,660	540	10-8	do	do	55	-----	120±	do	Not used at present.
458	¼ mile north of Hazleton	Wyoming Valley Water Co.	Saddle	1,660	-----	-----	-----	Pottsville	-----	Flows	150	do	
459	½ miles south- west of Hazle- ton	Giles Phillips	Hillside	1,720	100	6	Sandstone	do	18	6	65	D	Small draw-down pumping 65 gallons a minute.
460	1 mile south of Harwood	Wyoming Valley Water Co.	do	1,760	-----	-----	-----	do	-----	Flows	-----	P S	There are several wells nearby, but only this one flows.

¹ If no distance is given well is in town.² Generally estimated from nearest contour line or bench mark on topographic map.³ B—Bottling; C—Cooling; D—Domestic; H—Hospital; I—Industrial; N—None; PS—Public Supply; SP—Swimming Pool.⁴ From instrumental survey by Stanton Operating Co.

Analyses of waters in Luzerne County

[Parts per million. Numbers less than 1200 correspond to numbers on map and in the table of well data].

	269	278	301	313	334	342	358	394	401
Silica (SiO ₂)		6.3				16			
Iron (Fe)		.05				.06			
Calcium (Ca)	12 ¹	8.6		4 ¹	10 ¹	33	53	11 ¹	20 ¹
Magnesium (Mg)		1.4				6.8	16		
Sodium (Na)	10 ²	3.1		2 ²	146	35	42 ²	4 ²	8 ²
Potassium (K)		1.0				1.0			
Bicarbonate (HCO ₃)	94	24	94	25	133	121	59	56	86
Sulphate (SO ₄)	3 ¹	13	11 ¹	4 ¹	6 ¹	9.9	97	6 ¹	2 ¹
Chloride (Cl)	3.0	2.5	2.0	(³)	168	53	48	1.0	2.0
Nitrate (NO ₃)	1.5	.91		.10	(³)	.0	55	.20	11
Total dissolved solids	89 ²	48	97 ²	27 ²	393 ²	224	371 ²	57 ²	93 ²
Total hardness as CaCO ₃ (calculated)	64 ⁴	27		20	32	110	198	46 ⁴	68 ⁴
Date of collection (1930)	Sept. 16	Sept. 16	Sept. 16	Sept. 16	Sept. 16	Sept. 16	Sept. 16	Sept. 15	Sept. 15

	415	435	451	1203 ⁵	1204 ⁵	1205 ⁵	1206 ⁵	1207 ⁵	1208 ⁵
Silica (SiO ₂)		4.8							
Iron (Fe)		.04							
Calcium (Ca)	11 ¹	25	2 ¹		12 ¹	2 ¹	(⁶)	1 ¹	7 ¹
Magnesium (Mg)		7.0							
Sodium (Na)	11 ²	11	4 ²		7 ²	4 ²	(⁶)	2 ²	4 ²
Potassium (K)		1.9							
Bicarbonate (HCO ₃)	64	24	10	32	31	11	4	7	23
Sulphate (SO ₄)	12 ¹	11	(⁶)	13 ¹	9 ¹	8 ¹	(⁶)	1 ¹	2 ¹
Chloride (Cl)	2.0	32	(³)	3.0	3.0	1.0	1.0	1.0	4.0
Nitrate (NO ₃)	.10	50	.10		9.0	.10	.10	.20	4.8
Total dissolved solids	74 ²	182	13 ²	50 ²	56 ²	22 ²	10 ²	10 ²	35 ²
Total hardness as CaCO ₃ (calculated)	45 ⁴	91	4 ⁴		32 ⁴	10 ⁴	3 ⁴	3 ⁴	22 ⁴
Date of collection (1930)	Sept. 15	Sept. 15	Sept. 15	Sept. 17	Sept. 16	Sept. 16	Sept. 15	Sept. 15	Sept. 15

¹ By turbidity.

² Calculated.

³ Less than 1 part.

⁴ Determined.

⁵ 1203. Spring $\frac{1}{4}$ mile northwest of Harding; sand and gravel in stream channel; temperature 56° F. 1204. Spring $\frac{1}{2}$ mile northeast of Trucksville; glacial drift; temperature 52° F. 1205. Spring $\frac{1}{2}$ mile northeast of Wapwallopen; glacial drift; temperature 52° F. 1206. Spring $\frac{1}{2}$ miles northeast of Bear Creek; sand in glacial drift; temperature 55° F. 1207. Spring 1 mile southeast of Glen Summit; sand in glacial drift; temperature 49° F. 1208. Spring $\frac{3}{4}$ mile southwest of White Haven; glacial drift (?); temperature 54° F.

⁶ Less than 2 parts.

Analysts: 269, 278, 301, 342, 394, 415, 435 1203, 1207, 1208, L. A. Shinn; 313, 334, 358, 401, 451, 1204, 1205, 1206, K. T. Williams.

Log of Smith well, Fairmount Springs

[Well 256, p. 145 and fig. 11]

	Feet		Feet		Feet
Soil -----	0- 52	"Salt" sand, red;		Sandstone, hard --	855- 865
Rock, hard -----	52- 62	salt water (?) --	316- 361	"Slate", blue -----	865- 869
Rock, red -----	62- 107	Rock, hard -----	361- 369	Shale -----	869- 872
Rock, hard -----	107- 113	Shale, red -----	369- 377	Sandstone -----	872- 917
Rock, red -----	113- 253	Rock, red -----	377- 383	"Slate", (sandstone	
Sandstone -----	253- 270	Not recorded -----	383- 517	24 feet) -----	917-1416
Rock, red -----	270- 316	"Slate", blue -----	517- 855	"Slate", sandy ----	1416-1500

Log of Stanton Operating Co.'s well 1, near Harding

[Well 294, p. 148, and figs. 5, 11]

	Feet		Feet
Soil -----	0-20	Sand -----	57-60
Clay and boulders -----	20-27	Clay sand -----	60-63
Clay, boulders, and gravel -----	27-40	Sand clay -----	63-68
Sand -----	40-42	Clay, boulders, and gravel -----	68-93.5
Clay and sand -----	42-57		

Log of Stanton Operating Co.'s 10-inch well, near Harding

[Well 295, p. 148, and fig. 11]

	Feet		Feet
Fine sand and loam -----	0-19	Sand and gravel, little clay -----	60-64
Sand and gravel -----	19-24	Sand and gravel -----	64-68
Coarse sand -----	24-29	Sand and fine gravel, little clay -----	68-73
Gravel -----	29-41	Sand and gravel (loose), no clay ----	73-83
Sand -----	41-44	Sand and gravel (40% sand), little clay	83-89
Sand, gravel and clay -----	44-57	Sand and some gravel -----	89-98
Sand and gravel -----	57-60		

Log of Croup well, Hunlock Creek

[Well 334, p. 151, and fig. 11]

	Feet		Feet
Soil, boulders, hardpan, etc. -----	0- 60	Sandstone, gray -----	160-172
Rock, red and dark gray -----	60- 70	Shale, red -----	172-204
Rock, red and light gray -----	70- 75	Sandstone, blue-gray, medium hard --	204-210
Rock, red -----	75- 80	Sandstone, blue-gray, hard -----	210-224
Rock, light gray -----	80-110	Sandstone, green, medium hard -----	224-295
Rock, dark gray -----	110-115	Sandstone and shale, soft, red -----	295-365
Shale, red -----	115-160	Sandstone, gray, water-bearing ----	365-375

Log of Wyoming Valley Water Co.'s well, near Derringer

[Well 394, p. 157 and fig. 11]

	Feet		Feet
Sand and gravel -----	0- 25.5	Sandstone, red -----	246 -256
Conglomerate -----	25.5- 44	Conglomerate -----	256 -307
Crevice (bit dropped) -----	44 - 46	Sandstone, green -----	307 -322
Conglomerate -----	46 - 59	Sandstone, red -----	322 -352
Crevice, few (?) inches ¹ -----	59 - 62	Sandstone, green ³ -----	352 -367
Conglomerate -----	62 - 81	Conglomerate -----	367 -392
Sandstone, dark -----	81 - 87	Shale, red -----	392 -425
Soapstone (?) -----	87 - 90	Sandstone, green -----	425 -433
Sandstone, fine-grained -----	90 -112	Conglomerate -----	433 -455
Sandstone, green -----	112 -117	Sandstone, green -----	455 -459
Sandstone, red -----	117 -122	Shale, red -----	459 -482
Sandstone, green -----	122 -144	Shale, green -----	482 -485
Conglomerate -----	144 -160	Sandstone, green -----	485 -500
Crevice, few (?) inches ² -----	160 -182	Shale, red -----	500 -562
Sandstone, green -----	182 -190	Sandstone, gray -----	562 -564
Sandstone, red -----	190 -199	Shale, red -----	564 -602
Sandstone, green -----	199 -229	Sandstone, gray -----	602 -652
Conglomerate -----	229 -234	"Slate", green -----	652 -661
Sandstone, Green -----	234 -238	"Slate", red -----	661 -678
Sandstone, red -----	238 -239	Sandstone, gray -----	678 -680
Sandstone, green -----	239 -246	Shale, red -----	680 -689

¹ Water-bearing "slate".

² Water-bearing conglomerate.

³ Water-bearing (large yield).

Log of Jeddo Highland Coal Co.'s well near Sandy Run

[Well 426, p. 160 and fig. 11]

	Feet		Feet
Surface material -----	0- 10	Sandstone, gray -----	190-215
Conglomerate -----	10- 75	Sandstone, red -----	215-255
Sandstone, gray -----	75- 85	Sandstone, green -----	255-320
Conglomerate -----	85-100	Sandstone, red -----	320-340
Sandstone, gray -----	100-127	Sandstone, green -----	340-365
Sandstone, green -----	127-144	Sandstone, red -----	365-393
Sandstone, red -----	144-184	Sandstone, green -----	393-405
Sandstone, green -----	184-190	Sandstone, red -----	405-689.5

Log of Jeddo Highland Coal Co.'s well near Freeland

[Well 439, p. 162 and fig. 11]

	Feet		Feet
Surface soil -----	0- 32.6	Sandstone, green -----	356 -368
Conglomerate, gray -----	32.6- 68	Shale, red -----	368 -384
Sandstone, gray, and conglomerate -----	68 -165	Sandstone and shale, green and red -----	384 -396
Sandstone, gray -----	165 -182	Sandstone, green -----	396 -407
Sandstone, red and green -----	182 -215	Shale, red -----	407 -422
Sandstone, light green -----	215 -234	Sandstone, green -----	422 -438
Sandstone and shale, red and green -----	234 -256	Sandstone, light green -----	438 -456
Sandstone, green -----	256 -274	Sandstone, red and green -----	456 -471
Shale, red -----	274 -328	Sandstone and shale, red -----	471 -485
Sandstone, light green -----	328 -356	Shale, red -----	485 -506.5

Log of Wyoming Valley Water Co.'s well near Drifton

[Well 440, p. 162 and fig. 11]

	Feet		Feet
Clay, yellow -----	0- 18	Sandstone and shale, green and red -----	321-399
Conglomerate, light-colored -----	18- 55	Sandstone, green -----	399-411
Conglomerate, yellow -----	55- 73	Sandstone, light green -----	411-430
Conglomerate, gray -----	73- 90	Sandstone, gray -----	430-446
Sandstone, gray -----	90-130	Sandstone, green -----	446-462
Sandstone, yellow and green -----	130-160	Shale, red -----	462-480
Sandstone, light-colored -----	160-200	Sandstone, red and green -----	480-509
Sandstone, light green -----	200-218	Shale, red -----	509-523
Sandstone, green -----	218-253	Sandstone, light green -----	523-533
Sandstone, light green -----	253-268	Sandstone and shale, red and green -----	533-554
Sandstone, green -----	268-288		
Shale, red -----	288-321		

Log of Jeddo Highland Coal Co.'s well near Jeddo

[Well 444, p. 163 and fig. 11]

	Feet		Feet
Surface -----	0- 16	Sandstone, green -----	646- 665
Conglomerate -----	16- 140	Shale, red -----	665- 709
Sandstone, green -----	140- 205	Sandstone, red -----	709- 739
Shale, red -----	205- 218	Shale, red -----	739- 860
Sandstone, green -----	218- 281	Sandstone, red -----	860- 886
Shale, red -----	281- 291	Shale, red -----	886- 897
Conglomerate, green -----	291- 352	Sandstone, red -----	897- 912
Shale, red -----	352- 381	Shale, red -----	912- 945
Sandstone, gray, hard -----	381- 438	Sandstone, red -----	945- 976
Shale, red -----	438- 476	Shale, red -----	976- 992
Sandstone, green -----	476- 497	Sandstone, red -----	992-1,000
Shale, red -----	497- 646		

Log of Jeddo Highland Coal Co.'s well near Jeddo

[Well 446, p. 163 and fig. 11]

	Feet		Feet
Fault gauge -----	0-140	Sandstone, red -----	338-358
Sandstone, white -----	140-180	Sandstone, green -----	358-373
Conglomerate -----	180-210	Sandstone, gray -----	373-386
Sandstone, green -----	210-230	Conglomerate -----	386-456
Sandstone, gray -----	230-270	Shale, red -----	456-512
Sandstone, green -----	270-285	Conglomerate -----	512-573
Crevice -----	285-286	Sandstone, green -----	573-578
Sandstone, gray -----	286-306	Sandstone, red -----	578-593
Sandstone, white -----	306-338	Sandstone, green -----	593-596

Log of Jeddo Highland Coal Co.'s well near Jeddo

[Well 447, p. 163 and fig. 11]

	Feet		Feet
Surface -----	0- 21	Sandstone, gray -----	295-303
Sandstone, yellow -----	21- 55	Sandstone, green -----	303-335
Shale, blue -----	55- 66	Sandstone, dark green -----	335-351
Conglomerate -----	66-108	Conglomerate -----	351-423
Sandstone, yellow -----	108-113	Sandstone, gray -----	423-427
Conglomerate -----	113-147	Sandstone, red -----	427-435
Sandstone, dark -----	147-153	Sandstone, gray -----	435-437
Sandstone, gray -----	153-175	Not recorded -----	437-508
Conglomerate -----	175-184	Sandstone, green -----	508-522
Sandstone, green -----	184-196	Sandstone, red -----	522-548
Conglomerate -----	196-239	Sandstone, green -----	548-557
Sandstone, yellow -----	239-243	Conglomerate -----	557-613
Sandstone, gray -----	243-292	Sandstone, green -----	613-619
Sandstone, yellow -----	292-295	Sandstone, red -----	619-634

Log of Jeddo Highland Coal Co.'s well at Ebervale

[Well 450, p. 163 and fig. 11]

	Feet		Feet
Clay and gravel -----	0- 11	Sandstone, dark -----	130-162
Sandstone, gray -----	11- 23	"Rock", yellow -----	162-173
Sandstone, dark -----	23- 31	Conglomerate -----	173-299
Sandstone, light -----	31- 35	Sandstone, green -----	299-347
Sandstone, dark -----	35- 59	Conglomerate -----	347-381
Coal (Alpha coal ?) -----	59- 60	Sandstone, green -----	381-428
Sandstone, dark -----	60- 72	Shale, green -----	428-433
Conglomerate -----	72-130	Shale, red -----	433-450

Log of Jeddo Highland Coal Co.'s well at Harleigh

[Well 455, p. 164 and fig. 11]

	Feet		Feet
Wash -----	0- 10	"Slate", blue, sandy -----	338-356
Sandstone -----	10- 30	Sandstone, green -----	356-407
Conglomerate -----	30- 47	Conglomerate, fine -----	407-470
Sandstone, dark blue -----	47- 51	Sandstone, green -----	470-497
Sandstone, dark -----	51- 73	Sandstone, red -----	497-502
"Slate" -----	73- 76	Sandstone, green -----	502-510
Coal -----	76- 77	Conglomerate, fine -----	510-602
Sandstone, dark -----	77- 82	Sandstone, green -----	602-626
Sandstone, gray -----	82- 93	Sandstone, red -----	626-636
Conglomerate, fine -----	93-130	Sandstone, green -----	636-647
Sandstone, dark -----	130-139	Conglomerate, fine -----	647-698
Conglomerate, fine -----	139-245	Sandstone, green -----	698-757
Coal (Alpha bed ?) -----	245-248	Sandstone, red -----	757-762
"Slate", blue, sandy -----	248-258	Sandstone, green -----	762-800
"Slate", dark blue, sandy -----	258-262	Sandstone, gray -----	800-808
Conglomerate, coarse -----	262-334	Sandstone, red -----	808-855
Conglomerate, blue -----	334-336	Sandstone, green -----	855-895
Conglomerate, coarse -----	336-338		

Log of Jeddo Highland Coal Co.'s well near Ebervale

[Well 456, p. 164 and fig. 11]

	Feet		Feet
Clay -----	0- 24	Sandstone, green -----	276-285
Shale -----	24- 30	Sandstone, red -----	285-295
Sandstone, light-colored -----	30- 78	Sandstone, green -----	295-326
Conglomerate -----	78-153	Sandstone, red -----	326-349
Sandstone, light-colored -----	153-178	Sandstone, green -----	349-384
Sandstone, green -----	178-207	Sandstone, red -----	384-472
Sandstone, light-colored -----	207-216	Sandstone, green -----	472-477
Sandstone, green -----	216-241	Sandstone, red -----	477-493
Sandstone, light-colored -----	241-261	Sandstone, green -----	493-497
Sandstone, green -----	261-268	Shale, red -----	497-519
Sandstone, red -----	268-276	Sandstone, green -----	519-566.7

MONROE COUNTY

GENERAL FEATURES

[Area 623 square miles; population 28,286]

Monroe County borders the State of New Jersey in the east-central part of Pennsylvania. In 1930 East Stroudsburg had 6,099 and Stroudsburg had 5,961 inhabitants, but all the other boroughs in the county had less than 1,000. In the same year there were 1,370 farms in the county, and in 1929 there were 64 manufacturing establishments with annual products valued at \$5,000 or more each. The scenic Delaware Water Gap and the Pocono Mountains have attracted thousands of tourists and vacationists to the summer resorts in this county, most of which are scattered along the famous Lackawanna Trail.

SURFACE FEATURES

In the western part of Monroe County there is a high plateau known as the Pocono Mountains. Its eastern rim, which is 1,800 to 2,100 feet above sea level, towers about 1,000 feet above the country to the east and contains Pimple Hill, and Kistler Ledge, both 2,215 feet above sea level, and Dresser Hill, 2,220, the highest points in the county. The nearly flat plateau has been cut into from the west by Lehigh River, down to an altitude of 1,400 feet. East of the Pocono Mountains the country slopes rapidly down to Delaware River in the northern part and to Pohopoco and McMichael Creeks in the southern part. In the region southwest of the Delaware Water Gap is a series of long high ridges separated by narrow valleys and broken in places by wind and water gaps. Kittatinny Mountain, the highest of these, forms the southern boundary of the county and has a nearly uniform altitude of 1,500 to 1,600 feet. The lowest point in the county, where Delaware River leaves the county through the Delaware Water Gap at an altitude of 280 feet, is also the point of greatest local relief, for precipitous walls of the gap rise more than 1,100 feet above the river. The maximum relief in Monroe County is 1,940 feet.

The eastern two-thirds of Monroe County, most of which lies below the Pocono Plateau, is drained by Delaware River and its tributaries. The western third, including most of the Pocono Plateau and a small area below the plateau in the southeastern part of the county, is drained by Lehigh River and its tributaries.

GEOLOGY AND GROUND WATER

GENERAL SECTION

Monroe County was not entirely covered during the last advance of the ice. The Wisconsin drift border traverses the northern part of Tunkhannock Township, swings around Camelback Mountain (Pocono Knob), passes through the towns of McMichael, Brodheadsville, and Saylorsburg, follows the north slopes of Kittatinny (Blue) Mountain, and crosses that mountain at Fox Gap. The earlier (Illinoian) drift border passes through Polk, Eldred, and Ross Townships and joins the

Wisconsin border just southwest of Saylorsburg. The Wisconsin terminal moraine is clearly outlined throughout most of its course, particularly on the Pocono Plateau, where it is marked by an irregular series of low hills or mounds. The evidence of Illinoian glaciation is less clearly preserved.

There are several extensive buried valleys in Monroe County. The largest of these is a continuation of the Delaware buried valley that begins near Bushkill, where Delaware River turns southward to cut through Wallpack Ridge, extends through to Stroudsburg and then to Sciota, where it bifurcates, one branch passing through Brodheadsville and thence following Pohopoco Creek to Lehigh River in Carbon County, and the other branch continuing southwest from Sciota along Lake Creek and then descending the valley of Buckwha Creek for a short distance. Cherry Creek flows over another of these buried valleys. Huge mounds of drift are scattered along these buried valleys, particularly in the vicinity of Snydersville.

The rock formations exposed in Monroe County range in age from the Mount Pleasant formation of the Catskill continental group down to the base of the Tuscarora sandstone.

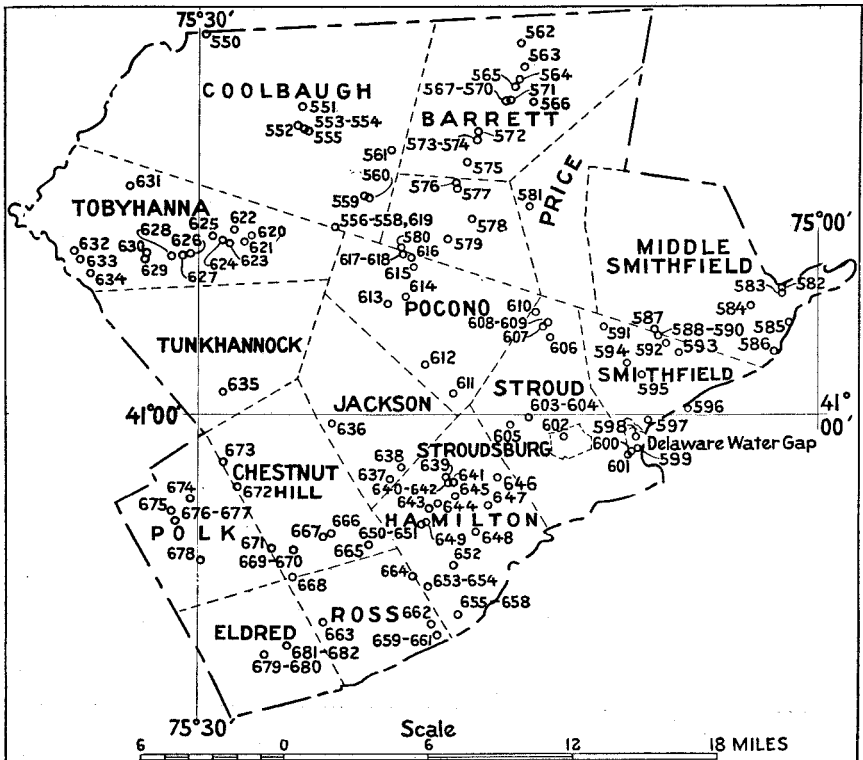


Figure 12. Map of Monroe County showing location of water wells

Generalized section for Monroe County

Geologic unit	Maximum thickness exposed (feet)	Character of rocks	Ground-water conditions
Glacial drift (Wisconsin and Illinoian)	200±	Clay, sand, "quicksand" and gravel; chiefly "quicksand" in some places.	Gravel beds yield small supplies of water; "quicksand" causes difficulties in drilling. Supplies numerous dug wells and springs. Water is very soft and low in dissolved mineral water.
Catskill group	4,000±	Red, green, and gray shales and sandstones and conglomerate.	Yields moderate to large supplies of very soft water. Flowing wells locally.
Portage group	1,700±	Blue and black sandy fossiliferous shales, olive-green and gray micaceous sandstones.	Sandstones yield moderate supplies, shales yield small supplies of potable water. Water may contain hydrogen sulphide.
Hamilton formation	1,400±	Limestone, 30 feet, at top; rest is bluish-gray sandstone and sandy "slate". Somewhat fossiliferous.	Yields moderate supplies of water of good quality. Sandstone yields more than shale.
Marcellus shale	800±	Bluish-gray and bluish-black sandy shale; bituminous black slate in southern part of county.	Yields small but reliable supplies of potable water; 1 flowing well with large yield.
Onondaga formation	450	Dark-gray cherty limestone (200 feet) underlain by hard gray sandy shale (Esopus 250 feet).	Solution channels in limestone yield moderate to large supplies; solid limestone, somewhat fractured, yields small supplies. Water softer than typical limestone waters. No well data available for lower shale. Character suggests that it is probably a fairly good water-bearing formation.
Oriskany sandstone	175±	Coarse sandstone and conglomerate alternating in eastern part of county with beds of chert.	Very few wells; high permeability but outcrop areas largely rocky and uninhabited. Water reported to be of good quality.
Helderberg limestone	415	Limestone interbedded with sandy shale and sandstone.	Very few data available; would probably yield an adequate supply of water if solution channels were encountered.
Cayuga group	1,500 to 2,000	Bossardville limestone underlain by Wills Creek shale (calcareous shales and thin beds of limestone) and Bloomsburg red beds (red shale, red and variegated shales and sandstone).	A good water-bearing formation. Upper calcareous part yields moderate supplies of hard water; water in lower part probably soft.
Clinton formation	1,600±	Variegated shales and sandstone, ferruginous sandstone, hard white and green sandstone or quartzite, hard quartz conglomerate.	Excellent water-bearing formation; large supplies of water of excellent quality; many flowing wells.
Tuscarora sandstone	200—225	Coarse quartz conglomerate, vitreous white sandstone or quartzite; small amount of shale.	No wells; unimportant because of topographic position.

STRUCTURE

The structure of the northern part of Monroe County is similar to that of Pike County, with gently dipping or horizontal beds on the Pocono Plateau increasing rapidly in dip toward Delaware River, to the southeast. The structure becomes increasingly complex along the strike of the beds toward the southwest, where there are several folds with northeasterly axes. A minor anticline traverses the Pocono Plateau, and in the resulting syncline to the southwest lies Camelback Mountain (Pocono Knob). The Wallpack anticline forms Wallpack Ridge and broadens the outcrops of the Lower Devonian strata. Numerous minor folds occur in the vicinity of East Stroudsburg at the southwest end of the Wallpack anticline. The Kemmerville anticline elevates the Silurian and Lower Devonian strata between the Delaware Water Gap and Sciota. Southern Monroe County is traversed by a series of folds which, from northwest to southeast are as follows: The northeastern tip of the Nesquehoning anticline extends into the northern part of Polk Township; the Mauch Chunk syncline, which rises rapidly from Lehigh River eastward, probably extends a short distance into Polk Township; the Lehighton anticline extends northeast from Schuylkill and Carbon Counties along Pohopoco Creek nearly to Stroudsburg; south of the Lehighton fold is the Wire Ridge syncline, extending northeastward nearly to Sciota. The dips along the Wallpack and Kemmerville anticlines are 25° to 30° ; those along the Lehighton anticline are 30° to 40° in Monroe County and steeper to 70° to 90° in Carbon County.

WATER-BEARING FORMATIONS

[See pp. 41-67 for further description]

Glacial drift.—Glacial drift deposits of variable thickness cover most of the county north of the Wisconsin drift border and a good part of the territory south of this border. A large part of the drift filling the buried valleys just described consists of stratified fine sand, known to the well drillers as "quicksand" because it flows into the bottom of the well casing. A good exposure of "quicksand" may be seen in the road cut just south of Bushkill (pl. 7-B). In drilling through thick beds of such material some of the drillers keep the hole filled with water, which allows the casing to sink easily. Unless layers of water-bearing gravel are encountered it is usually necessary to drill through the drift into the bedrock. It is reported that in Paradise Valley, which is filled largely with "quicksand," drilled wells obtain small supplies of water from beds of gravel at depths of about 55 and 165 feet (well 578). In Shoemaker, Stroudsburg, and Brodheads ville the depth of the drift ranges from 150 to 180 feet, but on account of the quicksand nearly all the drilled wells obtain water from the underlying bedrock.

Glacial drift supplies numerous dug and driven wells and a few drilled wells with water of very good quality, but no large supplies of water have been developed in the drift.

Several flowing wells obtain water from beds or lenses of gravel overlain by impervious beds of clay and fine sand (wells 614, 634, and 669). A flowing well (well 625) at Pocono Lake obtains water from the Catskill, but it is reported that a stronger flow was obtained in "quicksand" at a depth of 40 feet.

Several springs yield small to very large supplies of exceptionally soft water from the glacial drift. The spring of the Stroudsburg Water Supply Co., about 1½ miles northwest of East Stroudsburg, is reported to yield more than 1,000,000 gallons a day. The water issues from beds of sand about 100 yards from Paradise Creek and probably enters the beds at some point farther upstream. (See analysis 1209).

Catskill continental group.—The Pocono Plateau and a large area below the plateau is entirely underlain by the Catskill continental group including all beds from the Analomink to the lower part of the Mount Pleasant. Deposits of glacial drift conceal the bedrock in most parts of the plateau and well logs are not available from which to determine in all cases the true nature of water-bearing beds. However, in most places the water is reported to come from hard sandstone or conglomerate.

The Catskill yields moderate to exceptionally large supplies of very soft water to drilled wells, many of which are less than 100 feet deep. The 285-foot drilled well of the U. S. artillery camp near Tobyhanna (well 551) yields 320 gallons a minute continuously and is the strongest well reported in the county. Two other wells (620-621) are reported to yield more than 100 gallons a minute. Most of the other wells are used only for domestic purposes and yield adequate supplies of very good water. Four flowing wells were recorded from the Catskill on the Pocono Plateau, despite the simple geologic structure.

Portage group.—The Portage group crops out in a narrow northeast-southwest belt and in two narrow belts around the Wire Ridge syncline.

It is not an important source of ground water in Monroe County because of its narrow area of outcrop. Very few records were obtained of wells in this formation. The thin-bedded sandstones yield adequate supplies of potable water, and the sandy shales will probably yield small supplies of water, some of which contains hydrogen sulphide.

Hamilton formation.—The Hamilton formation in northeastern Monroe County generally forms a belt of hills from 1 to 1½ miles wide, but between Stroudsburg and Sciota the outcrop is about 2½ miles wide. At Sciota the Hamilton outcrop bifurcates and continues to the southwest around both sides of the Wire Ridge syncline. The Hamilton decreases in thickness and becomes finer in texture toward the southwest. Records of wells indicate that yields of 5 to 15 gallons a minute can be obtained from the shales or "slates," and well 664 yields 20 gallons a minute from sandstones in the lower part of the Hamilton. One analysis of water in sandstone indicates that the water from the Hamilton is very soft and relatively free from dissolved mineral matter. The water in the shales is probably slightly harder than that in the sandstones and in some wells contains hydrogen sulphide.

Marcellus shale.—The Marcellus shale crops out in a long sinuous strip a quarter of a mile to a mile wide near the southeastern border of Monroe County. It consists entirely of shale or "slate," which erodes readily and forms valleys. In southern Monroe County the black slates at the base of the Marcellus are very bituminous and resemble coal where they have been metamorphosed by strong folding. Brown hematite iron ore occurs locally in the black slates and has been mined at several localities to use in the manufacture of mineral paint.

Although shale is in general relatively impermeable, most of the Marcellus shale is brittle and has been fractured enough to allow some movement of ground water. Drillers report that although the yield of wells in the Marcellus is likely to be small, rarely over 5 gallons a minute, yet it is almost certain to be adequate for domestic purposes. The only strong well recorded in the Marcellus flows 30 gallons a minute and would probably yield considerably more by pumping (well 645). It is possible, however, that a part of the water in this well is derived from the 140 feet of "quicksand" that overlies the shale.

Water from the Marcellus in some localities is reported to be slightly hard, and an analysis of water from well 645 shows a hardness of 110 parts per million. In the southern part of the county, where deposits of hematite occur near the base of the Marcellus, the water is likely to contain excess iron.

Onondaga formation.—The Onondaga formation, comprising the upper cherty limestone member and the lower Esopus shale member, crops out in a long narrow belt across the county. The coarse hard Esopus shale member covers large areas with bare rocks, especially along Wallpack Ridge. The Onondaga is 450 feet thick in the eastern part of the county but is probably less than 100 feet thick at the Carbon County line.

Where solution channels containing water are encountered the cherty limestone member yields 20 to 30 gallons a minute and would probably yield more if larger pumps were used. Wells penetrating solid limestone free from large openings usually yield at least 5 gallons a minute, as the limestone in most places is well fractured, owing to folding. The flint nodules contained in the limestone cause great difficulty in drilling, especially when a large nodule is struck off center resulting in a crooked hole. The water in the limestone is generally reported to be hard, but an analysis of water from well 592 showed a hardness of only 148 parts per million, which is less than the hardness of most typical limestone waters.

Well data are not available for the Esopus shale member because its outcrop areas are in most places steep and rugged and devoid of habitation, but its coarse sandy character suggests that its water-bearing properties would be about midway between those of a shale and a sandstone.

Oriskany sandstone.—The outcrop of the Oriskany sandstone forms a narrow ridge in the southeastern part of the county. Unlike the overlying Onondaga formation the Oriskany thickens toward the southwest, increasing to 45 feet at Brodheads Creek and to about 175 feet at the west line of Monroe County. At Brodheads Creek the Oriskany consists of vertical or overturned beds of conglomerate and chert with a bed of pebbly sandstone at the top, but at the western county line it consists of a massive conglomeratic quartz sandstone. It is well fractured and shattered and disintegrates readily.

Very few well data were collected for the Oriskany sandstone. In general it stands nearly vertical and forms a ridge containing very little culture of any kind. Records of a few domestic wells yielding about 5 gallons a minute do not indicate the maximum yields obtainable. The sandstones and conglomerates, unlike most of the Paleozoic sandstones, are porous and are well fractured, so that the rock appears to have con-

siderable permeability. Thus if the formation cropped out at a lower angle under a fertile farming belt it would undoubtedly be an important source of water. A 350-foot well in Saylorsburg (653) is reported to yield 150 gallons a minute from clay or shale which is probably disintegrated Oriskany. The Universal Cement Co. east of Saylorsburg has mine workings extending down 120 to 180 feet into the disintegrated Oriskany and pumps 25 to 30 gallons a minute for 10 hours each day. The water in the Oriskany is reported to be of good quality.

Helderberg limestone.—The Helderberg limestone crops out below the Oriskany throughout the southern part of the county and is well exposed at numerous limestone quarries, but the limestone that is quarried commercially is largely from the underlying Bossardsville limestone of the Cayuga group.

Very little is known about the water-bearing properties of the Helderberg in Monroe County, but it includes numerous beds of massive limestone that may contain water-bearing solution channels, and also contains sandstones that may be water-bearing. A well near Bossardsville (well 647), in the Helderberg, is 80 feet deep and yields about 5 gallons a minute.

Cayuga group.—In Monroe County the Cayuga group crops out in the Delaware River Valley between Wallpack Bend and the Delaware Water Gap, continues in Cherry Creek Valley to Ross Common, and crops out in the Aquashicola Creek Valley to the western line of the county. The Cayuga group includes, in descending order, the Bossardville limestone, 73 feet thick; the Poxono Island shales and limestones of I. C. White, about 210 feet thick (Wills Creek shale); and the Bloomsburg red beds, about 1,260 to 1,500 feet thick. The Cayuga rocks are in general soft and form valleys throughout their courses, and their outcrops are largely covered by glacial drift. The Bossardville limestone is the chief quarry limestone of the region and has been mined for many years.

From the scanty data available, the Cayuga appears to be a good water-bearing formation. Three wells (585, 586, 596) obtaining water from beds of limestone range in depth from 70 to 108 feet and yield from 25 to 50 gallons a minute. The upper part of the Cayuga contains numerous beds of limestone favorable for the formation of water-bearing solution channels. Moreover, there are beds of brittle, thinly laminated limestone which have been well fractured by folding and allow relatively free movement of ground water. The Bloomsburg red beds in the lower part would probably yield a little water, and they are associated with beds of sandstone that should yield ample quantities. No samples were collected from wells in the Cayuga of Monroe County. The upper Cayuga of Northumberland County yields water that is satisfactory for domestic use, but far too hard for boilers. The water in the Bloomsburg shales and sandstones might be expected to be much softer than that in the upper calcareous part.

Clinton formation.—The Clinton formation crops out along the north slope of Kittatinny Mountain and probably forms the crest of the mountain in most places. The outcrops are steep and heavily wooded in most places, and these rocks have been used extensively as a source of ground water only near Delaware Water Gap and Wind Gap.

With one exception (well 598) all the wells in the Clinton yield large supplies of excellent water. The structural conditions are very

favorable for flowing wells, in that numerous beds of hard, well-fractured sandstone or quartzite dip steeply to the north and crop out along the higher parts of Kittatinny Mountain, where they receive ample recharge of ground water from rainfall. Locally these water-bearing beds are effectually sealed off above by beds of shale and yield water under artesian head sufficient in some places to produce flowing wells.

At the Delaware Water Gap wells 599 to 601, ranging in depth from 140 to 215 feet, yield 25 to 60 gallons a minute, and one well being pumped at 40 gallons a minute is reported to be capable of 100 gallons a minute. Well 598, nearby, is 500 feet deep and is reported to yield only 1 or 2 gallons a minute. Near Ross Common, north of the Wind Gap, the Blue Mountain Water Co. (supplying the town of Wind Gap, in Northampton County) has eight strong wells (655-662), four of which flow a few gallons a minute. They range in depth from 187 to 459 feet and yield from 100 to 200 gallons a minute, with an average yield of 140 gallons a minute. The yield apparently does not increase with depth, for the deepest well yields about 130 gallons a minute and the strongest well is only 227 feet deep. The water from all wells in the Clinton is reported to be of good quality. (See analysis 601, p. 192.)

Tuscarora sandstone.—The Tuscarora sandstone is the oldest formation exposed in Monroe County except for a small area of the Martinsburg shale that may extend into the county a short distance at the Delaware Water Gap. The Tuscarora crops out near or just south of the crest of Kittatinny Mountain and is well exposed at the Delaware Gap. It is not important as a source of ground water because of its topographic position, and no wells that obtain water from it were observed.

ARTESIAN CONDITIONS

The structure of Monroe County is favorable to artesian conditions in many places, and such conditions are found locally even where the structure is not wholly favorable. A glance at the table of well data below will show that the water level in most of the wells stands considerably above the point at which water was first encountered, and some of the wells flow. Artesian conditions are not limited to the hard-rock formations but are also present locally in the glacial drift.

On top of the Pocono Plateau several flowing wells in the glacial drift obtain water from lenses of gravel overlain by beds of impervious clay or "hardpan" (wells 614, 634, 669). Several flowing wells also obtain water from sandstones of the Catskill on top of the plateau (wells 553, 554, 623, 625). There are several scattered flowing wells in the region below the plateau, but here again the flowing wells occur locally, and there are no regions where flowing wells may be expected with surety. The best artesian conditions in the county appear to be along the north flank of Kittatinny Mountain where the Clinton formation and to some extent the Cayuga group supply several flowing wells and it is possible that other flowing wells might be obtained here.

QUALITY OF WATER

Samples of water were collected from 12 wells and springs in Monroe County, the analyses of which are tabulated on page 192. Five samples from wells and springs in the glacial drift were very low in dissolved solids and hardness. The samples from wells and springs in the hardrock formations were generally soft. A sample collected from a well in the cherty limestone member of the Onondaga formation had

163 parts per million of total dissolved solids and 148 parts per million of hardness.

It is significant that the ground waters of Monroe County are exceptionally soft and low in dissolved mineral matter, and that the sample collected from limestone compares favorably in hardness with waters from sandstones and shales in other regions and is considerably softer than typical limestone water. The relative softness of this limestone water is attributed to the fact that the Onondaga is a rather thin formation with steep dips, so that the ground water contained in it has probably not moved very far through limestone and consequently has not had opportunity to dissolve much of the rock. No samples of water were collected from the thicker limestone beds of the Helderberg and Cayuga, but it is believed that the water in these limestones is harder than that from the Onondaga. The water in the lighter-colored rocks, such as the Catskill, Bloomsburg, and Clinton, is exceptionally soft, whereas the water from dark-colored marine shale and sandstone, such as the Portage, Hamilton, and Marcellus, is somewhat harder and may contain small amounts of hydrogen sulphide. An analysis of water from a well in the Marcellus shale showed 135 parts per million of total dissolved solids and 110 parts per million of hardness. Iron in undesirable amounts was not found in any of the samples collected but may be present in waters from highly ferruginous rock such as the iron-ore beds of the Clinton formation and the paint ore in the Marcellus. In general the ground waters of Monroe County are so low in dissolved mineral matter that they are likely to corrode iron water pipes, and this trouble was experienced by the Stroudsburg Water Co.

PUBLIC SUPPLIES

Nine communities in Monroe County that use ground water for public supply are listed in the subjoined table. East Stroudsburg, Swiftwater, and Buck Hill Falls are reported to use surface water exclusively. Shawnee was reported to use some spring water, but data were not available for tabulation. Most of the places using ground water are supplied wholly or in part by springs in the glacial drift, but some are supplied from drilled wells. Stroudsburg, the largest borough in the county, obtains 1,000,000 gallons daily from a spring in the glacial drift. (See p. 174 and analysis 1209, p. 192.) The Blue Mountain Consolidated Water Co., which supplies several places in Northampton County, obtains the major part of its water from small streams and 8 drilled wells (655 to 662) in Monroe County near Ross Common.

DOMESTIC AND INDUSTRIAL SUPPLIES

Most of the industries of Monroe County are located in the boroughs, such as Stroudsburg and East Stroudsburg, and use public water supply. Several creameries and clay companies obtain water from drilled wells for washing and boiler use. The Pocono Manor Hotel obtains a large supply of water from springs, but probably the largest private supply is that of the United States artillery camp north of Tobyhanna (well 551). There are innumerable small springs in the county, particularly on the Pocono Plateau, and a great many of them are used for domestic supply. Some dug wells are still in use in the southern part of the county, but it is believed that most of the domestic supplies are obtained from springs or drilled wells.

Public water supplies in Monroe County derived from ground water

Community and Population ¹	Owner	Source	Geologic source	Storage (gallons)	Average daily con- sumption gallons	Consumers	Treatment	Remarks
Delaware Water Gap 443 -----	Water Gap Water Co.	Small stream 1 spring 2 drilled wells	Spring, glacial drift; wells, Clinton	321,000	-----	120	Chlorine gas (stream only)	See well 600 and 601; analysis 601.
Mountain Home -----	Mountain Home Water Co.	Spring and auxiliary stream sup- ply	Spring, glacial drift	10,000	-----	28	do	
Mount Pocono 466 -----	Fairview Water Co.	1 spring	Glacial drift (?) -----	320,000	200,000	-----	None	See analysis 1210.
Pocono Lake Preserve -----	Pocono Lake Preserve	3 springs	Glacial drift -----	15,000	-----	120	do	See analysis 1212.
Pocono Pines -----	F. Miller	1 spring 1 drilled well	Spring, glacial drift; well, Catskill	28,500	9,000	-----	do	See well and analysis 620.
Saylorsburg -----	Hamilton Water Co.	5 springs 1 drilled well	Springs, glacial drift; well, Hamilton	100,000	-----	110	do	See well and analysis 664.
Stroudsburg 5,961 -----	Stroudsburg Water Supply Co.	1 spring 1 lake (auxiliary for fire)	Spring, glacial drift	8,500,000	*1,000,000	-----	do	See analysis 1209.
Tannersville -----	Cramer Lumber Co.	2 springs	Glacial drift -----	1,200	-----	12	do	
Tobyhanna -----	Ray Brittain	1 drilled well	Catskill -----	1,100	-----	*50	do	See well and analysis 552.

¹ Figures available only for incorporated places.

² 30 percent used by railroads.

³ 10 percent used by railroad.

Drilled wells in Monroe County

No.	Location ¹	Owner or tenant	Topographic situation	Altitude above sea level ² (feet)	Depth (feet)	Diameter (inches)	Character of material	Geologic horizon	Depth to which well is cased (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
550	Coolbaugh Township 2½ miles south-west of Gouldsboro	C. O. Ellis	Upland	1,840	63	6	-----	Catskill	30±	10±	20	D	Air lift maintains constant pressure of 85 pounds; pump operates 24 hours a day; bedrock is overlain by 150± feet of gravel and sand. See analysis 552; temperature 48°F, Sept. 22, 1930. Well has flowed continuously since 1910; temperature 48°F.; water reported to be soft. Water level is 2 feet above the surface 10 months a year, and at the surface 2 months; small flow; pumped at 60 gallons a minute without cessation of flow; it is reported that the water level begins to rise about a week after a heavy rain. Well is unfinished; small draw-down pumping 8 gallons a minute
551	1 mile north of Tobyhanna	U. S. artillery camp	do	1,900	285	8	-----	do	150±	-----	320	do	
552	Tobyhanna	Tobyhanna Water Co.	do	1,960	160	6	-----	do	80	80	large	P S	
553	do	F. Micelli	do	1,900	85	4	-----	do	30	flows	2-3	D	
554	do	J. K. Wismer & Son	do	1,900	76	5	Hard fine-grained sandstone	do	30	do	60+4	do	Hard sandstone between depths of 20 and 30 feet.
555	do	Tobyhanna High School	do	1,900	90	6	Hard red sandstone	do	49	20	8	do	
556	Pocono Summit	Pocono Summit Hotel	do	1,828	60±	-----	-----	do	29	-----	-----	do	
557	do	L. L. Lyons	do	1,828	60	-----	-----	do	-----	20	-----	do	
558	do	Mr. Miller	do	1,828	35	-----	-----	do	20	-----	-----	do	Hard sandstone between depths of 20 and 30 feet.
559	1 mile north of Mount Pocono	F. M. Bisbee	do	1,900	50	-----	Sandstone	do	20	20	-----	do	
560	do	Chas. Richards	do	1,900	65	6	Fine conglomerate	do	30	20±	10	do	

561	3 miles north of Mount Pocono	A. Meyers	Hillside	1,980	100	6	Sandstone	do	23	23	26	do	Small draw-down pumping 26 gallons a minute; drift (cased) 28 feet, hard conglomerate 60 feet, sandstone (water-bearing) 12 feet.
562	Barrett Township 2½ miles north-east of Canadensis	Skytop Hotel	Hilltop	1,580	470	-----	-----	do	-----	40	40	do	
563	1½ miles north-east of Canadensis	John Snow	Hillside	1,420	130	6	Gray sandstone	do	10	70-80	15	do	Cased 10 feet, red shale 90 feet, gray sandstone 30 feet.
564	1½ miles north-east of Canadensis	S. Shaverly	do	1,260	208	6	Quartz conglomerate	do	20	175	40	do	
565	¾ mile north-east of Canadensis	Mr. Brown	do	1,180	224	6	Blue sandstone and red shale	do	20	6	2+	do	Small draw-down pumping 2 gallons a minute; drift (cased) 20 feet, blue sandstone 180 feet, red shale 24 feet.
566	1 mile east of Canadensis	W. Siese	do	1,300	185	6	Gray sandstone	do	10	85	1-	do	Well unfinished, large draw-down pumping one gallon a minute; drift (cased) 10 feet, red shale 100 feet, gray sandstone (some water) 75 feet.
567	Canadensis	Rufus Snow	Valley	997	49	6	Hard gray sandstone	do	15½	7	20	do	Small draw-down, pumping 20 gallons a minute.
568	do	G. F. Fuller	do	997	70	6	do	do	30	18	80	do	Small draw-down pumping 80 gallons a minute.
569	do	-----	do	-----	220	6	-----	do	88	90	15	do	Small draw-down pumping 15 gallons a minute; bedrock overlain by 88 feet of drift containing numerous boulders.
570	do	-----	do	-----	75	6	-----	do	65	4	-----	do	
571	do	Amanda Heckman	Hillside	1,000±	63	6	Hard sandstone	do	8	10	15	do	
572	¼ mile north of Mountain Home	C. W. King	Upland	1,220	140	-----	-----	do	40	30	30	do	
573	Mountain Home	G. H. O'Hara	do	-----	100	-----	Red sandstone and shale	do	23	30	1	do	
574	do	Peter Castle	do	-----	135	6	do	do	50	30	30	do	
575	Cresco	Mr. Shannon	do	1,200	198	6	-----	do	4	60	5	do	
576	Paradise Township 1 mile south of Cresco	Tilman Hawk	Hillside	1,180	210	6	Yellow sandstone	do	60	125	80	do	

Drilled wells in Monroe County—Continued

No.	Location ¹	Owner or tenant	Topographic situation	Altitude above sea level ² (feet)	Depth (feet)	Diameter (inches)	Character of material	Geologic horizon	Depth to which well is cased (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
577	1½ miles south of Cresco	Wilmer Tea Room	Hillside	1,179	80	-----	Gravel	Glacial drift	80	68	8	D	Well does not reach bedrock; water encountered in gravel below "quicksand."
578	Paradise Valley	(Average record)	Valley	-----	165	-----	do	do	165	-----	-----	do	In Paradise Valley the bedrock is overlain by more than 165 feet of glacial drift consisting of alternate layers of gravel and "quicksand"; water is found in gravel beds at various depths, especially at about 55 and 165 feet; no wells are reported to have entered the bedrock; much difficulty is encountered in casing through the "quicksand."
579	1½ miles south-west of Paradise Valley	G. Safin	do	1,030	130	6	Gray sandstone	Catskill	30	35	5	do	Small draw-down pumping 5 gallons a minute; drift (cased) 30 feet, red shale 70 feet, gray sandstone (water-bearing) 30 feet; drill cuttings were reported to have been removed by water circulating through seams in the gray sandstone; small amounts of vegetable matter occasionally enter the well through these seams.
580	¾ mile north-west of Swift-water	Miller's Garage	do	1,274	98	-----	-----	do	-----	-----	40	do	
	Price Twp.												
581	4¼ miles south of Canadensis		do	780	1,800±	6	-----	Portage	-----	flows	50±	N	Flowing well, reported not to fluctuate; temperature 52°F.; water contains some hydrogen sulphide; drilled for oil.

582	Middle Smithfield Twp. Shoemaker	N. A. Ahnert	Valley	440±	120	6	Limestone	Onondaga	90	60-	17±	D	Small draw-down pumping 17± gallons a minute; bedrock overlain by 90 feet of "quicksand"; water reported to be hard. Bedrock overlain by 180 feet of sand and "quicksand"; water reported to be hard.
583	do	Alvin DeWitt	do	460±	200	6	do	do	180	30±	-----	do	
584	1 mile east of Coolbaugh	Fawn Cabin	do	500	86	6	do	do	6-8	24	-----	do	
585	1½ miles south of Shoemaker	Camp Miller	Hillside	360±	90	6	Soft limestone	Cayuga	40	40	25	do	Exact location not known; bedrock overlain by 40 feet of sand and gravel. Flows 4 or 5 gallons a minute; water level 6 to 7 feet above the surface; draw-down 6 feet below the surface pumping 40 gallons a minute; data given are for 1912.
586	2½ miles south of Shoemaker	W. R. Webb	Valley	340	70	6	Limestone	do	6	flows	40	do	
587	½ mile north of Marshall Creek Smithfield Twp.	H. Huffman	Hillside	620	67	6	Shale ?	Marcellus	25	25±	-----	do	
588	¾ mile north of Marshall Creek	do	do	560	120	-----	-----	do	40±	10±	-----	do	Water level very low during the summer; leaky casing allows surface water to contaminate the well. Water reported to be hard. Large draw-down pumping 5 or 6 gallons a minute. Water level reported to fluctuate considerably.
589	½ mile north of Marshall Creek	J. Huffman	do	550	87	6	-----	do	25±	-----	-----	do	
590	¼ mile north of Marshall Creek	do	do	560	250	-----	-----	do	-----	-----	5-6	do	
591	2 miles north-west of Craig Meadows	S. Weil	do	820	85	6	-----	do	25	30±	10	do	Water reported to be hard; see analysis 592; temperature 52°F., Sept. 22, 1930; some water in drift at 16 feet; drill struck a cavern in the limestone at 87 feet, and the water rose within 18 feet of the surface. Large draw-down.
592	Marshall Creek	N. Huffman	Valley	470	87	8	Cavernous limestone	Onondaga	30-40	18	20	do	
593	1 mile south-east of Marshall Creek	W. Eschenback	Hilltop	800	160	6	Hard brown sandstone	Oriskany	9	4	5	do	
594	¾ mile south-west of Craig Meadows	W. Schoonover	Hill	560	87	6	Limestone	Onondaga	30	12	small	do	

Drilled wells in Monroe County—Continued

No.	Location ¹	Owner or tenant	Topographic situation	Altitude above sea level ² (feet)	Depth (feet)	Diameter (inches)	Character of material	Geologic horizon	Depth to which well is cased (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
595	$\frac{1}{2}$ mile south of Craig Meadows Pahaquarry Twp., N. J.	G. Nye	Hillside	700	150	6	Sandstone	Oriskany	6-8	25	5	D	
596	Buckwood Park, N. J. Smithfield Twp.	-----	Valley	300	108	8	Limestone	Cayuga	40	-----	50	do	Small draw-down pumping 50 gallons a minute.
597	Experiment Mills	Dr. Heard	do	360	80	6	Hard "slate" and limestone	do	20	flows	-----	do	
598	Delaware Water Gap	Ed. Houser Mountain House	Valley	320	500	6	Hard "rock" (sandstone)	Clinton	30	4-5	1-2	do	Large draw-down pumping 1 or 2 gallons a minute. Can be pumped only 4 hours a day.
599	0.4 mile south-east of Delaware Water Gap	Riverview House	Hillside	500	215	6	do	do	6	40	25	do	Small draw-down pumping 25 gallons a minute.
600	0.4 mile south of Delaware Water Gap	Water Gap Water Co.	do	500	180	8	do	do	shallow	20	40	P S	Pumped at 40 gallons a minute but reported to be capable of 100 gallons a minute.
601	$\frac{1}{2}$ mile south-west of Delaware Water Gap Stroud Twp.	do	do	400	140	4	do	do	do	0	60	do	Water level stands at the surface; see analysis 601; temperature 67°F., Sept. 22, 1930.
602	Stroudsburg	Indian Queen Hotel	Valley	420	250	-----	Black slate	Marcellus	172	8-10	-----	D	Bedrock overlain by 172 feet of drift; gravel 8 feet, "quick-sand" 154 feet, black slate 78 feet.

603	1 $\frac{1}{2}$ miles north-west of Stroudsburg	Mrs. LaPlume	Hillside	640	200	-----	do	Hamilton	30	40-50	-----	do	Some hydrogen sulphide at times.
604	do	Mrs. Atchison	do	640	200	6	do	do	30	40-50	-----	do	
605	2 $\frac{1}{2}$ miles west of Stroudsburg	Mr. Kitner	do	700	100	6	Black shale	do	100	Dry	-----	do	Well unfinished; bedrock overlain by 100 feet of drift.
606	$\frac{3}{8}$ mile south of Analomink	Miller's Garage	Valley	500 \pm	84	6	Black shale and slate	Portage	39	4	-----	do	Gravel (cased) 4 feet, "quick-sand" (cased) 35 feet, black shale and slate, very hard (water-bearing), 45 feet.
607	Analomink	Mr. Hardy	Hillside	550 \pm	72	6	Red sandstone	Catskill	27	18	-----	do	
608	$\frac{1}{4}$ mile north-east of Analomink	Mr. Detrich	Canyon	560 \pm	62	-----	Gray sandstone	do	-----	16 \pm	45?	do	Water level has been as high as 8 feet below the surface.
609	$\frac{1}{4}$ mile north-east of Analomink	Mr. Pencil	do	580 \pm	40	-----	-----	do	6	8-10	large	do	Flows after a heavy rain; some water at a depth of 19 feet.
610	$\frac{3}{8}$ mile north of Analomink	L. D. Sulphur	Lakeside	660	125	6	Gray sandstone	do	8	6 \pm	do	do	Red shale (some water) 22 feet, gray sandstone (water-bearing in lower part) 103 feet.
	Pocono Twp.												
611	$\frac{3}{8}$ mile north-west of Bartonsville	Black Cat Restaurant	Hillside	830	105	-----	-----	Portage	39	$\frac{1}{2}$	12	do	Draw-down . inches pumping 12 gallons a minute.
612	$\frac{3}{8}$ mile west of Lower Tanersville	J. W. Dean	do	940	102	-----	Hard gray sandstone	Catskill	16-18	22	-----	do	Drift and red shale 16-18 feet, hard gray sandstone (water-bearing) 74-96 feet; some water in the red shale, but a dug well 18 feet deep goes dry during the summer.
613	1 mile west of Scott Run	H. Schock	do	1,280	62 $\frac{1}{2}$	6	Red sandstone	do	10	15	15	do	
614	0.5 mile north of Scot Run	L. L. Rhodes	Hillside	1,160	84	6	Coarse gravel	Glacial drift	84	flows	10	do	During the summer of 1930 the water level dropped to 6 feet below the surface; temperature 53° F.
615	0.3 mile south of Swiftwater	Mr. Hallstead	Valley	1,200	48	6	-----	Catskill	20 \pm	9	-----	do	
616	Swiftwater	do	do	1,150	184	6	Red and gray sandstone	do	50	84	-----	do	Bedrock overlain by 50 feet of drift, "hardpan", and boulders; drill bit dropped 18 inches at the bottom; water encountered in this crevice.
617	0.3 mile north of Swiftwater	do	Hillside	1,280	98	6	-----	do	0	-----	-----	do	
618	do	Mrs. Tenant	do	1,280	220	-----	-----	do	-----	-----	-----	do	

Drilled wells in Monroe County—Continued

No.	Location ¹	Owner or tenant	Topographic situation	Altitude above sea level ² (feet)	Depth (feet)	Diameter (inches)	Character of material	Geologic horizon	Depth to which well is cased (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
619 620	Tobyhanna Twp. Pocono Summit Pocono Pines	Mr. Miller do	Upland Lakeside	1,830 1,780	65 78	----- -----	----- -----	Catskill do	4-5 -----	45± -----	----- 125	D P S	Well flows about 5 gallons a minute during wet seasons; see analysis 620; temperature 49° F., Sept. 22, 1930; pumping well lowers a spring 100 feet from the well.
621	do	Luther Land Association	Upland	1,800+	235	8	Soft brown sandstone	do	60	35±	105	do	Bedrock overlain by 60 feet of drift; draw-down 22 feet pumping 105 gallons a minute for 48 hours, but this draw-down is reached and maintained after a few hours of pumping.
622	½ mile north of Pocono Lake	Charles Gor- thrup	Lakeside	1,760	35	-----	Drift?	Glacial drift?	-----	15	15±	D	
623	Pocono Lake	Pocono Lake Hotel	Upland	1,751	53	-----	Shale	Catskill	50	flows	flow 7-8	do	Water is cloudy; bedrock overlain by 50 feet of "quicksand." Dug well deepened by drilling.
624 625	do do	Ephraim Hay	do Valley	1,760 1,680	35 79	----- 6	Hard sand- stone	do do	20 52	----- flows	30-40 5-6	do do	Water level stands 8 to 10 feet above the surface; bedrock overlain by 52 feet of glacial drift, ("quicksand" and boulders); strong flow of water struck at 40 feet in "quicksand"; this was cased off, although the flow was stronger than the present flow; temperature 48° F. Flow measurements: 6.18 gallons a minute, Aug. 13, 1930; 5.88 gallons, Sept. 22, 1930; 5.66 gallons, Oct. 17, 1930; 5.45 gallons, Sept. 17, 1931.

626	1 $\frac{1}{2}$ miles east of Pocono Lake Preserve	Mr. Armstrong	Hillside	1,660	62	-----	Yellow shale	do	15	10	15	do	
627	1 $\frac{1}{2}$ miles east of Pocono Lake Preserve	do	Lakeside	1,640	45	-----	do	do	10	10	12	do	
628	1 $\frac{1}{2}$ miles east of Pocono Lake Preserve	Mr. Moser	do	1,640	61	-----	do	do	-----	6	20	do	
629	$\frac{1}{4}$ mile south of Pocono Lake Preserve	Dr. Gibby	do	1,640	98	-----	-----	do	20	49	-----	do	
630	Pocono Lake Preserve	Pocono Lake Preserve	do	1,640	84	-----	Sandstone	do	20	30-40	-----	N	Water contains hydrogen sulfide.
631	3 $\frac{1}{2}$ miles north-east of Blake-slee	Carl Selig	Hillside	1,800	102	-----	Red shale	do	25	18	20	D	
632	$\frac{1}{4}$ mile south-east of Blake-slee	James Boyle	Upland	1,660	84	6	Hard sandstone	do	30	22±	-----	do	
633	1 mile south-east of Blake-slee	Morgan Thomas	do	1,676	143	-----	Sandstone	do	-----	10	-----	do	
634	1 mile north-west of Fern-ridge	Mr. Harrison	Valley	1,567	55	6	Gravel	Glacial drift	55	flows	2-3 $\frac{1}{2}$	do	Flowing well; well does not reach bedrock; artesian water in a gravel bed overlain by clay and 20 feet of sand; see analysis 634, temperature 48° F., Sept. 22, 1930. Flow measurements in gallons a minute 3.44 Aug. 14, 1930; 2.04, Sept. 22, 1930; 2.09, Sept. 17, 1931.
	Tunkhannock Twp.												
635	3 $\frac{1}{2}$ miles north of Merwins-burg	-----	Upland	1,850	20	-----	Outwash	do	-----	12±	-----	D	Dug well; flows during and after rain.
	Jackson Twp.												
636	$\frac{1}{2}$ mile east of McMichael	Mr. Fredericks	Saddle	1,100	130	-----	-----	Catskill	-----	-----	-----	do	
637	Neola	Mr. Carr	Hillside	809	80	6	Slate	Hamilton	40±	40	5±	do	
638	$\frac{1}{4}$ mile north-east of Neola	Sittig Camp	Hilltop	1,180	80	-----	Slate	do	40±	-----	5±	do	

Drilled wells in Monroe County—Continued

No.	Location ¹	Owner or tenant	Topographic situation	Altitude above sea level ² (feet)	Depth (feet)	Diameter (inches)	Character of material	Geologic horizon	Depth to which well is cased (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
639	Hamilton Twp. ¼ mile north of Snydersville	Detrich Bros.	Valley	520	84	-----	-----	Hamilton	30	9	-----	I	Use 5-horsepower suction pump; small draw-down.
640	Snydersville	M. S. Harps	do	500	180	6	Black slate	do	27	6-8	15	D	First water at 167 feet; water contains hydrogen sulphide; temperature 54° F., draw-down 20 feet pumping 15 gallons a minute.
641	do	Mr. Hegeman	Hillside	520	100	-----	do	do	20	40	5	do	Small draw-down pumping 5 gallons a minute; water contains hydrogen sulphide.
642	do	A. W. Courtwright	Valley	500	97	6	-----	do	25	6-15	-----	do	Depth to water level normally 6 feet; on Aug. 15, 1930, it was 12 to 15 feet.
643	¼ mile south of Sandhill	-----	Hillside	600	90	6	Slate	do	40	20	5	do	Small draw-down pumping 5 gallons a minute; bedrock overlain by 40 feet of clay.
644	0.3 mile north- west of Kellers- ville	Calvin Smith	Knoll	540	98	-----	Blue slate	do	31	20	15	do	Draw-down 14 feet pumping 15 gallons a minute for 15 minutes; water reported to be hard.
645	½ mile northeast of Kellersville	Monroe County Home	Valley	500	180	8	Black slate	Marcellus	140	flows	30	do	Measured flow 30 gallons a minute; bedrock overlain by 140 feet of quicksand; see analysis 645, temperature 54° F., Sept. 23, 1930.
646	2.1 miles east of Snydersville	Mr. Atchison	Hillside	460	100	6	Limestone	Onondaga	20	6-8	30	do	Small draw-down pumping 30 gallons a minute; water contains hydrogen sulphide at times.
647	1 mile north- east of Bos- sardsville	Mr. Heller	Hill	640	80	-----	do	Helderberg	-----	40	5	do	
648	Bossardsville	Mr. Reiner	Hillside	700	65±	6	-----	Oriskany?	18	18±	2	do	

649	$\frac{1}{2}$ mile northeast of Sciota	-----	do	560	100	-----	Slate	Marcellus	20	-----	3	do	
650	$\frac{1}{4}$ mile northeast of Sciota	-----	do	600	60	6	Black slate	do	10	20	-----	do	
651	do	-----	Hill	600	110	6	Slate	do	20±	-----	-----	do	
652	$1\frac{1}{2}$ miles north-east of Saylorburg	Crosby Clay Co.	Hillside	720	-----	-----	Limestone	Onondaga	45-50	45	4-5	I	
653	Saylorburg	Keystone Clay Works	Hill	744	350	8	Black shale	Oriskany	300+	100±	150	do	Drift 10 feet, white clay ?, black clay ?, black shale 50 feet, cased.
654	do	Mr. Holbrook	do	744	165	-----	-----	do	-----	-----	-----	D	
655	1 mile north-east of Ross Common	Blue Mountain Water Co.	Canyon	1,000	401	8	Red shale and sandstone	Clinton	12±	flows	130±	P S	Flows a few gallons a minute; considerable draw-down pumping 130± gallons a minute.
656	do	do	do	1,000	349	8	do	do	-----	do	130±	do	Wells 655-658 have been pumped at 130± gallons a minute day and night for months; now used only as auxiliary to a surface-water supply.
657	do	do	do	1,000	459	10-8	do	do	-----	-----	130±	do	200 feet, 10 inches in diameter; 259 feet, 8 inches in diameter.
658	do	do	do	1,000	371	10-8	do	do	-----	flows	130±	do	Flows a few gallons a minute pumped at 130± gallons a minute; first water at 45 feet; more water at 160 feet; at 180 feet and deeper the well flowed.
Ross Twp.													
659	Ross Common	do	Valley	840	187	8-6	do	do	12±	-----	150	do	Well 1; used as an auxiliary to a surface-water supply.
660	do	do	do	840	227	-----	do	do	12±	flows	200	do	Well 2; flows 50 to 60 gallons a minute; pumps 200 gallons a minute; pumping this well dries up the spring of the Ross Common Water Co.; pumping wells 1 and 3 has no effect on the spring.
661	do	do	do	840	261	-----	do	do	12±	-----	150	do	
662	$\frac{1}{2}$ mile north-west of Ross Common	do	Hillside	860	209	10	Red sandstone	do	30	-----	100	do	The rock in this well becomes harder with increasing depth; some conglomerate was encountered.
663	Rossland	J. Kleintop	do	805	58	6	Slate	Hamilton	15-18	18	-----	D	
664	$\frac{3}{4}$ mile north-west of Saylorburg	Hamilton Water Co.	Valley	680	210	6	Sandstone	do	70±	12	20	P S	Bedrock overlain by 70± feet of "hardpan" and clay; draw-down 6 feet pumping 20 gallons a minute; water reported to be soft; see analysis 664; temperature 54° F., Sept. 23, 1930.

Drilled wells in Monroe County—Continued

No.	Location ¹	Owner or tenant	Topographic situation	Altitude above sea level ² (feet)	Depth (feet)	Diameter (inches)	Character of material	Geologic horizon	Depth to which well is cased (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
665	Chestnuthill Twp. McIlhaney		Hillside	800	90		Soft shale	Hamilton	70	20	5	D	Bedrock overlain by 150 feet of glacial drift forming the terminal moraine; boulders 10 feet, "quicksand" 130 feet, clay 10 feet, slate 30 feet.
666	$\frac{3}{4}$ mile east of Brodheads-ville		Valley	740	180		Slate	do	150			do	
667	Broadheads-ville	W. L. Fehr	do	740	126		Slate ?	do	100	1½		do	
668	1 mile south of Weir Spring	Mr. Foster	Hillside	940	50		Hard red sandstone	Catskill	10	20	5	do	Well does not reach bedrock; water encountered in gravel. Well does not extend to bedrock; water-bearing gravel at a depth of 86 feet overlain by clay and "quicksand"; see analysis 670; temperature 52° F., Sept. 23, 1930.
669	Weir Spring	Mr. Henry	Lakeside	722	84	6	Gravel	Glacial drift	84	flows	5±	do	
670	do	Weir Lake Creamery	Valley	722	86	6	do	do	86	5-6	8	I	
671	Gilbert	Arthur Kromes	do	700	60	6		Hamilton	30	9		D	Abandoned well; water lost on deepening dug well by drilling.
672	$\frac{3}{4}$ mile south of Merwinsburg	Frank Murphy	Hilltop	1,080	50+			Catskill				N	
673	$\frac{3}{4}$ mile northwest of Merwinsburg	Mr. Bezisky	Hillside	1,150	90	6		do	50	40+		D	
674	Polk Twp. 0.8 mile east of Dottersville	Ernest Kreger	Hilltop	1,060+	152	6		do	shallow			do	

675	0.3 mile south of Dottersville	A. Serfoss	Hillside	920	37	-----	Red shale ¹	do	14	14	-----	do
676	$\frac{3}{4}$ mile south of Dottersville	R. F. Shupp	do	920	73	-----	Red shale and hard blue sandstone	Catskill?	21	20	-----	do
677	do	do	do	920	68	-----	-----	do	27	14	15±	do
678	Kresgeville Eldred Twp.	Mrs. Krome	Valley	699	75	6	-----	Hamilton	72	16±	-----	do
679	Kunkletown	J. Kleintop	do	529	80	-----	Slate	Marcellus	10	-----	5	do
680	do	J. Kleintop	do	529	78	6	Black slate	do	20	13	-----	do
681	1 mile northeast of Kunkletown	J. A. Gower	Hillside	600	48	6	Slate	do	11	30	-----	do
682	1 mile east of Kunkletown	G. Kleintop	do	680	110	6	do	do	10	50	-----	do

Water contains some iron.

¹ If no distance is given, well is located in town.

² Generally estimated from nearest contour line or bench mark on topographic map.

³ D—Domestic; I—Industrial; N—None; PS—Public Supply.

⁴ By pumping.

Analyses of waters in Monroe County

[Parts per million. Numbers less than 1200 correspond to numbers on map and in the table of well data.]

	552	592	601	620	634	645
Silica (SiO ₂)	---	---	---	---	---	---
Iron (Fe)	---	---	---	---	---	---
Calcium (Ca)	¹ 3	50	¹ 14	¹ 5	¹ 3	36
Magnesium (Mg)	---	5.5	---	---	---	4.9
Sodium (Na)	---	---	---	---	---	---
Potassium (K)	² 2	² 3	---	---	² 2	² 6
Bicarbonate (HCO ₃)	10	168	85	20	11	109
Sulphate (SO ₄)	³	¹ 15	¹ 12	³	¹ 2	¹ 26
Chloride (Cl)	3.0	1.0	3.0	1.0	1.0	5.0
Nitrate (NO ₃)	² 6.0	² 20	1.9	² 90	² 10	² 0
Total dissolved solids	² 24	² 163	² 95	² 22	² 14	² 135
Total hardness as CaCO ₃ (calculated)	⁴ 16	148	⁴ 90	⁴ 21	⁴ 9	110
Date of collection (1930)	Sept. 22	Sept. 22	Sept. 22	Sept. 22	Sept. 22	Sept. 23

	664	670	1209 ⁵	1210 ⁵	1211 ⁵	1212 ⁵
Silica (SiO ₂)	11	---	5.5	4.9	---	---
Iron (Fe)	.05	---	.02	.12	---	---
Calcium (Ca)	9.2	¹ 10	4.9	3.6	³	¹ 2
Magnesium (Mg)	2.1	---	1.5	1.1	---	---
Sodium (Na)	4.0	---	4.9	3.1	---	---
Potassium (K)	.2	² 7	0	.2	² 2	² 1
Bicarbonate (HCO ₃)	24	42	13	12	7.0	16
Sulphate (SO ₄)	14	¹ 4	9.4	1.4	³	³
Chloride (Cl)	1.8	1.0	2.8	4.0	1.0	1.0
Nitrate (NO ₃)	1.8	² 0	² 83	2.4	.0	² 10
Total dissolved solids	56	² 42	33	26	² 10	² 18
Total hardness as CaCO ₃ (calculated)	32	⁴ 24	18	14	⁴ 6	⁴ 14
Date of collection (1930)	Sept. 23	Sept. 23	Sept. 22	Sept. 22	Sept. 22	Sept. 22

¹ By turbidity.

² Calculated.

³ Less than 2 parts.

⁴ Determined.

⁵ 1209. Spring $1\frac{1}{2}$ miles northwest of East Stroudsburg; sand and gravel in glacial drift; temperature 60° F.

1210. Spring $\frac{1}{2}$ mile northeast of Mount Pocono; glacial drift (?); temperature 48° F.

1211. Spring $\frac{1}{4}$ mile southeast of Pocono Manor; Catskill group; temperature 48° F.

1212. Spring 1 mile southeast of Pocono Lake Preserve; glacial drift, temperature 48° F.

Analysts. 522, 601, 620, 634, 645, 670, 1211, 1212, K. T. Williams; 592, 664, 1209, 1210, L. A. Shinn.

MONTOUR AND NORTHUMBERLAND COUNTIES

GENERAL FEATURES

Montour County, area 130 square miles, population 14,517.
Northumberland County, area 454 square miles, population 128,504.

Montour and Northumberland Counties are described together because Montour County has a very small area, is like a corner out of Northumberland County and the topography, geology and ground-water conditions in the two counties are similar.

Montour County lies between Northumberland and Columbia Counties along the western border of the area here described and adjoins Lycoming County to the north. It is by far the smallest county described in this report. Nearly half of the inhabitants live in Danville, which has a population of 7,185. All the villages have less than 1,000 inhabitants each. In 1929 there were 23 manufacturing establishments in the county. Although no coal underlies Montour County, placer coal is dredged from the Susquehanna River. In 1930 there were 695 farms in the county.

Northumberland County lies along the southwestern border of the area covered by this report. The North and West Branches of Susquehanna River join at Northumberland, in the center of the county. Of the 20 largest municipalities in the area described in this report 3 are in Northumberland County—Shamokin, 20,274; Mount Carmel, 17,967; and Sunbury, 15,626. In 1929 there were 158 manufacturing establishments in the county with annual products valued at \$5,000 or more each. Most of the industrial development is along the West Branch of the Susquehanna as far south as Sunbury and in the Western Middle anthracite field, which occupies the southwest corner of the county. There were 28 coal mines in the county in 1930 and 2,143 farms.

SURFACE FEATURES

Montour County is unique in that its highest and lowest points are only 3 miles apart. The highest point is just west of Danville, where Montour Ridge is 1,425 feet above sea level. Three miles east of this point Susquehanna River leaves the county at an altitude of about 450 feet, so that the maximum relief is about 975 feet. Montour Ridge is the only high ridge within the county.

The highest point in Northumberland County is just southeast of Shamokin, where Mahanoy Mountain attains an altitude of 1,805 feet. Susquehanna River at the Dauphin County line is about 380 feet above sea level. A difference of 1,425 feet between these points gives a measure of the maximum relief in the county. There are a number of long, narrow ridges 1,200 to 1,700 feet in altitude, which rise 500 to 1,000 feet above the intervening valleys.

The southeastern third of Montour County drains into the North Branch of Susquehanna River, and the northwestern two-thirds drains into the West Branch of the Susquehanna. Northumberland County is drained entirely by Susquehanna River—the northern part by the West Branch, a small area in the middle part by the North Branch, and the southern part by the main river.

GEOLOGY AND GROUND WATER

GENERAL SECTION

Montour and Northumberland Counties lie south of the Wisconsin drift border, but the Illinoian border extends in a narrow strip down the North Branch of Susquehanna River as far as Selinsgrove and down the West Branch as far as Watsontown. Scattered deposits that may be Jerseyan drift have been traced as far south as Selinsgrove, along an east-west line through Northumberland County. Glacial outwash is

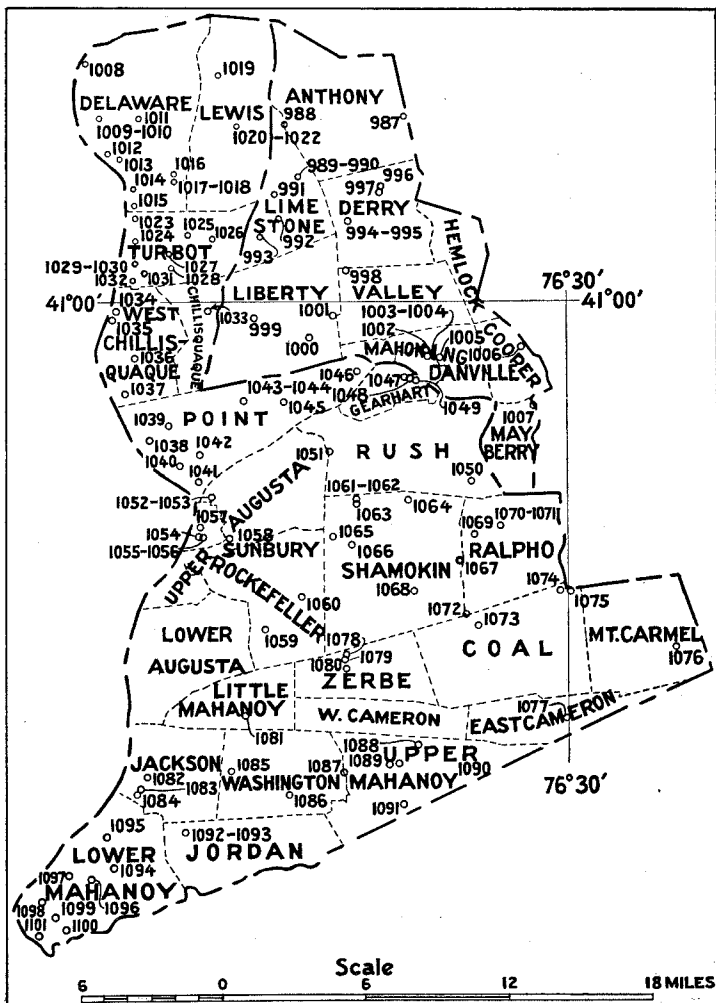


Figure 13. Map of Montour and Northumberland Counties showing location of water wells

found along both branches of the Susquehanna as far south as Selinsgrove and is the only glacial material of importance in the two counties.

The rock formations exposed in Montour County range in age from the Catskill group down to the Tuscarora sandstone; those in Northumberland County range from the post-Pottsville down to the Clinton.

Generalized section for Montour and Northumberland Counties

Geologic unit	Maximum thickness exposed (feet)	Character of rocks	Ground-water conditions
Glacial drift Wisconsin outwash, Illinoian drift and Jerseyan drift (?)	150, 2116	Illinoian drift and Wisconsin outwash along Susquehanna River; irregular deposits of clay, sand, quicksand and gravel.	Supplies few deep wells; no drilled wells reported to obtain water from sand or gravel, but gravel beds known to contain considerable potable water in some places.
Post-Pottsville formations	1,500±	Sandstone, shale, slate, fire-clay; 15 or 16 coal beds.	Unimportant; no wells reported; mine drainage used by collieries.
Pottsville formation	850±	Coarse conglomerate, gray and greenish sandstone and shale; 3 workable coal beds.	Unimportant; small area of outcrop on high, narrow ridges.
Mauch Chunk shale	2,000±	Largely red shale, with beds of red and green sandstone and green shale.	Yields small to moderate supplies of excellent water to shallow drilled wells. Sandstones yield large supplies to two municipal wells.
Pocono sandstone	800±	Coarse gray and yellowish sandstone and massive grayish-white conglomerate; some shale.	Yields large supplies of excellent water to a few municipal wells; wells flow 2 to 15 gallons a minute; unimportant for domestic wells because of steep outcrop.
Catskill group	2,000±	Red shale, red and gray cross-bedded sandstones, green and white sandstone; gray shale and sandstone in lower part.	Yields small to moderate supplies of good water to shallow wells; no deep wells reported.
Portage group	2,800±	Alternating beds of gray and olive-green shale and hard bluish or greenish sandstone, underlain by dark-blue and black shale and slate.	Yields small supplies of potable water to shallow wells; water reported to be medium hard in some places; no data obtained for Montour County. Hydrogen sulphide reported in some wells.
Hamilton formation	1,100±	Brown, gray, and bluish-gray sandy shale and sandstone.	Yield small to moderate supplies of water. In some places the water is very hard and contains hydrogen sulphide.
Marcellus shale	500±	Black and dark-blue fissile slates and shale.	
Onondaga formation	205	Hard light-gray impure limestone beds separated by thin layers of shale, underlain by light-gray shale.	Unimportant; only one well known; small areal extent.
Oriskany sandstone	154, 240	Fine-grained cherty sandstone, gray and brown sandy shale, and gray sandy cherty limestone.	Unimportant; supplies a few domestic wells with hard water.
Helderberg limestone	1263, 2235+	Largely pure, and impure beds of blue limestone, with some interbedded shale and hard sandstone.	Yields small to moderate supplies of hard water; numerous springs and sink holes.
Cayuga group	1,430±	Tonoloway limestone at top, 105 feet; Wills Creek shale, buff and pale-green limestone and shale, 329 feet; Bloomsburg red beds, red and green shale and sandstone, about 840 feet; McKenzie formation at base, greenish shale with some limestone, 156½ feet.	Bloomsburg red shale yields small to moderate supplies of good water; remainder (chiefly limestone and shale) yields moderate to large supplies of very hard water; numerous springs and sink holes.

Geologic unit	Maximum thickness exposed (feet)	Character of rocks	Ground-water conditions
Clinton formation	966	Fossil iron ore, hard reddish-brown ferruginous sandstone, green and red shale, some calcareous shale and limestone.	Unimportant; crop out only along crest of Montour Ridge.
Tuscorora sandstone	120	Sandstone.	

¹ Northumberland County.² Montour County.

STRUCTURE

The geologic structure of Montour and Northumberland Counties is very similar to that of Columbia County, to the east. The major folds trend in an easterly or slightly northeasterly direction, and some of them are complicated by two or more subordinate folds within the main structure. These folds are as follows, from north to south: Four anticlines enter northern Northumberland County from Union County—the Watson-town and Milton anticlines and two intermediate folds, exposing a broad belt of the Cayuga group. The Milton anticline persists into Montour County and continues northeastward into Lackawanna County, but the other folds die out largely in Northumberland County. The dips on the south side of the Milton anticline are in places 45° to 50°, but the dips on the northern side seldom exceed 20°, and dips as low as 5°N. were observed near Turbotville. South of this group of anticlines is the western extension of the Lackawanna syncline, exposing the Catskill in Montour County and the Hamilton in Northumberland County. South of this is the Berwick (Montour) anticline, exposing the Clinton formation along the crest of Montour Ridge, with dips of 40°-45° on both sides. The Northumberland syncline, exposing the Catskill formation, crosses through the borough of Northumberland and deepens rapidly toward the northeast. The Selinsgrove anticline crosses the Susquehanna River about 2 miles north of Selinsgrove and exposes the Cayuga group in Northumberland County. The strata dip 40°N. and 20°S. on this anticline, which is complicated by one or two minor folds on its north slope and one on its south slope. The Shamokin syncline exposes the post-Pottsville beds of the Shamokin and Mount Carmel coal basins and is complicated by numerous folds within the coal beds, the most pronounced of which is the Locust Mountain anticline, south of Mount Carmel. The Dalmatia anticline exposes a small area of the Cayuga group at the town of Dalmatia. This fold has a double crest with a sharp, narrow syncline between, so that there are two narrow belts of the Helderberg limestone exposed with dips of 40°-45° on the north side and of 70°-80° on the south side. A small subordinate anticline shown in plate 7-A arches the Hamilton formation about 2½ miles south of Dalmatia.

WATER-BEARING FORMATIONS

[See pp. 41-67 for further description]

Glacial drift.—The glacial drift borders in Montour and Northumberland Counties are shown on plate 1. A thin scattering of drift covers parts of the two counties, but the only glacial deposits of importance are those along Susquehanna River. The abandoned valley between Danville and Bloomsburg is described in the section on Columbia County. At the Danville end of this valley the bedrock channel appears to be deep, for well 1005 penetrated 60 feet of clay and hardpan, and 116½ feet of clay, sand, and gravel has been reported in Riverside. Well 1046 in Chulasky penetrated 81 feet of clay, sand, "quicksand," and gravel.

At least two terraces can be observed between Chulasky and Cameron, and drillers report that the gravel beds in this vicinity contain considerable water, but even though the water appears to be of good quality it is cased off in all the drilled wells in favor of a smaller supply from the underlying bedrock. Wells on Shamokin Island penetrate 39 to 45 feet of sand and water-bearing gravel, but here again the wells are finished in the bedrock. With properly constructed wells using screens or strainers it should be possible to obtain considerable water from the gravel beds in the glacial drift along the North Branch of the Susquehanna.

Broad terraces line the West Branch of Susquehanna River from Northumberland to the northern line of the county. In Delaware Township there appear to be two terraces at 20 and 40 feet above the river. At Watsonstown a deposit of sand occurs about 100 feet above the river, and farther south at Montandon two terraces are well defined. The first of these is 20 to 25 feet above the river and ends near the Pennsylvania Railroad tracks; the second is 50 to 60 feet above the river and appears to end against the low hills 1½ to 2 miles back and joins the low terrace south of Montandon. In this vicinity numerous dug wells are supplied by the sand and gravel, but the drilled wells are all cased through to the bedrock. Terraces are especially prominent between Montandon and Northumberland, and patches of coarse gravel may be seen covering the bedrock in the railway and highway cut high above the river. There are three terraces near Northumberland at 25, 55, and 80 feet above the river and a slight terrace 175 feet above the river.

C. A. Grove, a well driller at West Milton who is familiar with the region, reports that he has never encountered more than 50 feet of sand and gravel along the West Branch of the Susquehanna, and all the wells recorded obtain water from the underlying bedrock.

Sunbury is built on a low terrace, 20 to 25 feet above the river, but the depth to bedrock as indicated by well records is generally only 20 to 40 feet and in some places is only about 10 feet. Reefs of hard Portage sandstone can be observed at low water extending entirely across the main river opposite Sunbury, and at Shamokin Dam the same is true of the Hamilton sandstone, so that very little unconsolidated material is found on the east bank south of Sunbury, above Selinsgrove Junction, where a heap of rounded boulders extends up the east bank to a point about 215 feet above the river, near the Illinoian drift border. Below this point no drift material was seen, and no drilled wells that obtained water from sand or gravel were observed anywhere along the main river.

Post-Pottsville formations.—The post-Pottsville formations are not exposed in Montour County but crop out in Northumberland County in the large Shamokin-Mount Carmel coal basin, where they contain 15 or 16 beds of coal. No wells are known to obtain potable water from the post-Pottsville beds at the present time. One deep well south of Mount Carmel appears to obtain water from the underlying Pottsville formation or Mauch Chunk shale, but within the coal-bearing strata the water level has been greatly lowered by pumping from mines, and any water obtained would be likely to be polluted. M. Brown, engineer of the Philadelphia & Reading Coal & Iron Co., of Shamokin, reported that the amount of water pumped from mines during the summer of 1930 was far below normal and was insufficient to supply the collieries with water for washing coal, so that considerable water had to be purchased from municipalities. He stated further that during 1929 the Bear Valley Colliery, with workings down to a depth of 600 feet, pumped 1,101,587,062 gallons of water, which is an average of more than 3,000,000 gallons daily. Collieries in the deeper parts of the basin probably pump even more water.

Pottsville formation.—The Pottsville formation is not exposed in Montour County but crops out as a narrow ridge around the Shamokin-Mount Carmel coal basin and on several smaller ridges extending into the basin, such as Locust Mountain. The Pottsville contains numerous beds of conglomerate and sandstone that yield considerable water in regions to the east, where the beds lie at a lower angle, but in Northumberland County the beds dip steeply and the resulting high ridges are largely uninhabited, and therefore the Pottsville is unimportant as a source of ground-water. No wells are known on the outer rim of the Pottsville, but well 1076, drilled to a depth of 1,176 feet on the north slope of Locust Mountain, penetrates the Pottsville and may extend into the Mauch Chunk shale below. This well is cased 490 feet through the lowest Pottsville coal bed and had a reported flow of 120 gallons a minute of very good water in 1910. The flow gradually decreased, owing to mining activities, and stopped early in 1929, and the well is not used at present, although it would probably yield considerable water by pumping. (See log on p. 219.)

Mauch Chunk shale.—The Mauch Chunk shale is not present in Montour County but is exposed in Northumberland County in a long, narrow valley between Little and Line Mountains and the coal basin. Along Mahanoy Creek and Zerbe Run there are a few domestic wells in the Mauch Chunk ranging from 90 to 190 feet in depth and yielding 1 to 40 gallons a minute (well 1073). Two deep wells at Bear Gap (1074 and 1075) penetrate the lower part of the Mauch Chunk but appear to obtain their water from the underlying Pocono sandstone. Well 1076, near Mount Carmel, probably obtains part of its water from the Mauch Chunk. The Treverton Water Co. has two wells 140 feet deep (1079), spaced 8 feet apart, which flow 5 and 15 gallons a minute, and each well is pumped at 240 gallons a minute with small draw-down. The water obtained from the Mauch Chunk is of excellent quality.

Pocono sandstone.—The Pocono sandstone does not crop out in Montour County, but in southern Northumberland County it is exposed along a long high looped ridge comprising Little and Line Mountains. The

strata dip 40° to 45° toward the coal basin in most places and form very steep ridges.

The Pocono yields large supplies of water to several municipal wells along the south flank of Little Mountain. Wells 1074 and 1075 are 745 and 1,250 feet deep and flow 2 and 5 gallons a minute each. Well 1074 yields 120 gallons a minute continuously with small draw-down, and has been tested at 400 to 500 gallons a minute for 15 minutes with a draw-down of 340 feet. The other well would doubtless yield a large supply by pumping, but both wells have been abandoned because they dried up several springs nearby. The Trevorton Water Co. has a flowing well (1078) high on the mountain, of a rather unusual type. It is a diamond-drill hole 280 feet deep, drilled into the mountain at an angle of 45° from the end of an abandoned 150-foot tunnel. It is reported that two holes drilled horizontally were dry, but the 45° hole flows more than 5 gallons a minute. The water from the Pocono is of excellent quality.

Catskill continental group.—The Catskill continental group crops out in Montour County in a small synclinal area near New Columbia and in another synclinal area in Cooper and Mayberry Townships. In Northumberland County the Catskill crops out along the Northumberland syncline across the center of the county and in two broad belts around the Shamokin syncline in the southern part of the county.

The Catskill is relatively unimportant as a source of ground-water in Montour County as it crops out over a very small part of the county, but it supplies a few shallow drilled wells with an adequate quantity of good water.

In central and southern Northumberland County the Catskill supplies numerous shallow domestic wells with 1 to 18 gallons a minute. Some of the wells yielding only 1 to 1½ gallons a minute were not drilled deep enough to strike a good water-bearing sandstone. Well 1083, in the Catskill near Herndon, is 137 feet deep and yields about 50 gallons a minute. The water from this well is reported to be soft and entirely satisfactory for use in the textile plant.

Portage group.—The Portage group crops out along the northern boundary of the two counties, around the Lackawanna syncline in Montour County, around the Northumberland syncline in both counties and around the Selinsgrove and Dalmatia anticlines in southern Northumberland County. Portage shales and thin-bedded sandstones are shown in plate 5-B.

In Northumberland County several wells ending in the Portage yield adequate supplies for domestic use. Numerous thin-bedded sandstones occur in the Portage which allow some movement of ground water through fracture and bedding planes. Industrial wells, located principally in Sunbury, are 50 to 260 feet deep and are reported to yield 15 to 75 gallons a minute. In Deibler, well 1064, 80 to 100 feet deep, is reported to flow 20 gallons a minute and to yield considerably more by pumping. A driller reports that two out of four wells drilled in the Portage at Deibler flow and that in the other two the water stands within 1½ feet of the surface. An analysis of water from well 1056, in Sunbury, shows a hardness of 298 parts per million, which is considerably more than that of most Portage waters. In some of the wells the water was reported to contain some hydrogen sulphide. The Portage doubt-

less supplies a few domestic wells in southern Montour County, but no records were obtained.

Hamilton formation.—The Hamilton formation crops out around the Milton and Watsontown anticlines, the Lackawanna syncline, and the Berwick (Montour) anticline in Montour County and northern Northumberland County. In southern Northumberland County it is exposed around the Selinsgrove and Dalmatia anticlines. The character of the Hamilton, as well as the underlying Marcellus shale, changes radically from north to south (p. 56).

Wells in the Hamilton range in depth from 18 to 145 feet and with one exception yield only 3 to 8 gallons a minute, even though many of them end in sandy shale or sandstone. Well 1098 is 101 feet deep and yields about 20 gallons a minute from the Trimmers Rock sandstone. This well is just to the left of the stone quarry shown in plate 7-A. While the water obtained from the Hamilton is in general of better quality than that from the Portage and Marcellus, the latter formations appear to yield more water.

Marcellus shale.—The Marcellus shale crops out below the Hamilton formation in the regions described above for the Hamilton. Wells in the Marcellus range in depth from 72 to 200 feet and are reported to yield from 3 to 50 gallons a minute. Well 997, in Strawberry Ridge, Montour County, yields more than 25 gallons a minute of rather highly mineralized water containing some hydrogen sulphide (analysis 997). The water from this well is much harder than the typical limestone waters of northeastern Pennsylvania. Waters from the Marcellus in the southern part of the area are generally reported to be softer than those from the Marcellus in northern Montour and Northumberland Counties.

Onondaga formation.—The Onondaga formation crops out below the Marcellus shale on the Selinsgrove and Dalmatia anticlines.

The Onondaga is unimportant as a source of ground-water in Montour and Northumberland Counties. Well 1096 of the Dalmatia Water Company appears to draw water from the lower shale member but the exposures are poor in the vicinity of the well, and the geologic horizon is therefore questionable. This well flows during wet weather and yields about 10 gallons a minute by siphoning. The analysis shows the water to be moderately hard but satisfactory for most purposes.

Oriskany sandstone.—The Oriskany sandstone crops out as a narrow band around the Watsontown, Milton, Berwick (Montour), Selinsgrove and Dalmatia anticlines.

It is not important as a source of ground water, owing to its narrow outcrop and variable composition, but it supplies a few domestic wells in the northern part of the two counties, such as well 989. In general there are thin beds of cherty limestone in the Oriskany which cause the water in the sandstone to be hard.

Helderberg limestone.—The Helderberg limestone crops out in a narrow sinuous strip around the Watsontown and Milton anticlines, in two narrow strips on both sides of Montour Ridge, on the crest of the Selinsgrove anticline, and on both crests of the double anticline at Dalmatia.

Wells in the Helderberg range in depth from 48 to 293 feet and are reported to yield 5 to 25 gallons a minute. A sample of water from well

994, in Washingtonville, contained 514 parts per million of total dissolved solids and had a hardness of 210 parts per million. In addition to calcium bicarbonate, this sample contained considerable sodium sulphate, which is not found in other ground waters of this region and may be only a local phenomenon. Generally wells in the Helderberg yield about the same quantity and quality of water as those in the underlying Tonoloway limestone. Limestones of the Cayuga group below the Tonoloway generally yield larger supplies, but the water is very hard, and some of it is unfit for ordinary use.

Drillers report that limestone is the most uncertain type of rock encountered in this region, in that it may yield large quantities of water if solution channels are encountered but otherwise usually yields small quantities. Moreover if a solution channel is encountered in steeply dipping strata, a crooked hole may result when the drill bit strikes the slanting floor of the channel.

The Helderberg and Cayuga limestones contain numerous sink holes in northern Montour and Northumberland Counties and give rise to numerous small springs. The strongest limestone spring reported is the Molly Bullion Spring, owned by the Pennsylvania Railroad Co., just below the railroad tracks about 2½ miles northwest of Northumberland. This spring appears to be located on the Helderberg limestone, although no outcrops are visible. It yields normally an aggregate of about 500,000 gallons a day through two openings, in addition to a large quantity that escapes through the overflow pipe. The total flow was reduced to 100,000 gallons a day during the drought in the summer of 1930. The water is reported to contain about 100 parts per million of total dissolved solids, and is thought to come from a small stream that flows into a sink hole in one of the ravines to the northeast. Railroad officials report that several years before 1930 a large quantity of sawdust was dumped into the stream above the sink hole at 3 P. M., and that some of the sawdust came through to the spring at 9 A. M. next day. The water from this spring is treated with tan bark, chlorinated, and used as an auxiliary supply for drinking water and locomotive feed water.

Cayuga group.—The Cayuga group crops out over the broad anticlinal area between Dewart and Milton, extending as far east as California and Limestoneville. It also crops out in two broad bands on both sides of Montour Ridge and in small areas on the crest of the Selinsgrove anticline and the southern crest of the Dalmatia anticline.

On the Watsontown, Milton, and Berwick (Montour) anticlines the Cayuga is fully exposed. On the Selinsgrove and Dalmatia anticlines only the Tonoloway limestone and part of the Wills Creek shale are exposed.

The Tonoloway limestone generally yields about the same quantity and quality of water as the overlying Helderberg limestone. (See above). Wells 1005 and 1011 are believed to end in the Tonoloway. Well 1005 yields about 11 gallons a minute of moderately hard water. (analysis on p. 204).

The remainder of the Cayuga, except for the Bloomsburg red beds and underlying strata, consists principally of alternate beds of shale and limestone and with the Helderberg and Tonoloway limestone forms the only typical limestone region in northeastern Pennsylvania. The limestone occurs in northern Montour and Northumberland Counties on the Watson-

town, Milton, and intermediate anticlines. Here the Cayuga beds are folded very gently and form a broad, rolling valley area with low hills of Bloomsburg red beds near Susquehanna River. Sink holes, undrained depressions, and small springs are numerous, and the water in the small streams has an opalescent, milky appearance, which is typical of streams in limestone terranes. These features are not so pronounced on the Berwick (Montour), Selinsgrove, and Dalmatia anticlines, to the south, because the beds dip more steeply and consequently crop out over a much smaller area. Wells and springs in the Cayuga (exclusive of the Bloomsburg red beds) yield very hard water, but wells in the Bloomsburg generally yield smaller quantities of much softer water. The well drillers of the region agree that the Bloomsburg is a very reliable water-bearing formation in that it rarely fails to deliver a small supply of good water, whereas the limestone beds are more or less unreliable sources of water that is generally hard. Large supplies are often obtained from the limestones where solution channels are encountered, but the drillers report that weak wells result when no channels are encountered.

Domestic wells ending in Cayuga limestones range in depth from 24 to 136 feet and are reported to yield 1 to 15 gallons a minute. Industrial wells range in depth from 160 to 600 feet and yield from 10 to more than 150 gallons a minute. The water is generally excessively hard and cannot be used satisfactorily in boilers, because in addition to calcium bicarbonate it generally contains considerable sulphate, which forms hard scale.

Domestic wells in the Bloomsburg red beds are 50 to 100 feet deep and generally yield about 5 gallons a minute. In Danville the Geissinger Hospital wells (1003, 1004) are 528 and 592 feet deep, and each yields 26 gallons a minute with a draw-down of 172 feet. Although this amount of water is not adequate to supply the needs of the hospital, it would be sufficient for most industrial establishments. Well 1044 of the Northumberland Water Co. is 644 feet deep and yields 71 gallons a minute, presumably from the Bloomsburg beds (analysis on p. 204; log on p. 218).

Clinton formation and Tuscarora sandstone.—The Clinton formation and Tuscarora sandstone are exposed only by the Berwick (Montour) anticline along the crest of Montour Ridge. They are unimportant as sources of ground water in Montour and Northumberland Counties.

ARTESIAN CONDITIONS

One well in Montour County and about 14 wells in different parts of Northumberland County were reported to flow part or all of the time. Most of the flowing wells are on the flanks of anticlines or synclines. No locations for new flowing wells can be predicted with certainty, but the most likely place would be in the Pocono, Mauch Chunk, or Pottsville rocks around the Shamokin syncline. There are a few flowing wells in the Pocono and Mauch Chunk, and it is reported that before the advent of coal mining flowing wells were obtained in the post-Pottsville and Pottsville formations. Well 1076 of the Mount Carmel Water Co. illustrates very well the effect of mining activities in lowering artesian pressure. This well is 1,172 feet deep (see log on another page) and obtains water from either the Pottsville or the Mauch Chunk, or from both. In 1910 it had a reported flow of 120 gallons a minute, but the flow steadily decreased and in 1929 stopped altogether.

QUALITY OF WATER

The analyses of nine samples from drilled wells in Montour and Northumberland Counties are tabulated on page 204. Eight of the samples had from 102 to 523 parts per million of total dissolved solids, with an average of 300 parts, and an average hardness of 214 parts per million. This seems to indicate that the quality of the ground water in these two counties is not as good as it is in the other counties covered by this report. This is accounted for by the fact that these are the only counties in the area in which limestone is an abundant water-bearing rock, and therefore many of the samples are limestone water. In general the quality of water obtained from the Pottsville, Mauch Chunk, Pocono, Catskill, Hamilton, and Bloomsburg formations is reported to be very good, and about the same as in adjacent counties where samples were collected. The regions underlain by limestones of the Cayuga group (exclusive of the Tonoloway limestone) yield exceptionally hard water containing large amounts of sulphate, which causes the formation of hard scale in boilers.

The poorest sample of water collected in the entire area covered by this report came from well 1032 in Milton, from limestone of the Cayuga group. This sample contained 2,102 parts per million of total dissolved solids and had a hardness of 1,447 parts per million, due chiefly to calcium and magnesium sulphates. It also contained about 230 parts per million of sodium chloride (common salt) and 1.2 parts per million of iron. Such water is unfit for boiler use and for most industrial purposes and is used only for cooling and washing.

PUBLIC SUPPLIES

The three public water supplies using ground water in Northumberland County are tabulated below. Apparently no boroughs in Montour County use ground water for public supply. Danville takes water from Susquehanna River and all the villages depend on privately owned wells and springs. In Northumberland County very little ground water is being used for public supply, as all the larger places utilize surface water. Milton, Watsonstown, and other places in the limestone region are supplied by the White Deer Mountain Water Co., which obtains water from White Deer Mountain, across the river in Union County. Sunbury and the towns in the Shamokin-Mount Carmel coal basin are all supplied by surface water. A few drilled wells in and near the coal basin were formerly used for public supply, but they have since been abandoned.

INDUSTRIAL SUPPLIES

Very little ground water is used by industrial establishments in Montour County, as most of the industries are in Danville and use municipal water from the river. In Northumberland County the industrial users of ground water include 9 creameries, 4 silk or textile mills, 1 brick company, 1 meat packer, 1 ice company, 1 stone company, and several coal-washing plants. The ground water in the limestone region between Dewart and Milton is exceptionally hard and generally unsuitable for boiler use. The well of the Dairymen's Cooperative Association in Dewart was abandoned because of the poor quality of the water. Perhaps the largest industrial use of ground water in these counties is in the coal basins of southern Northumberland County, where mine drainage water is pumped out and used for washing coal.

DOMESTIC SUPPLIES

Domestic water supplies are still obtained largely from dug wells in the rural sections of Montour and Northumberland Counties. In the limestone region west of Dewart, Watsonstown, and Milton small springs are used for domestic supply, and it is reported that the spring water is not quite as hard as the water from drilled wells. The number of drilled wells is steadily increasing, and during the drought of 1930 many dug wells had to be deepened by drilling. In the southern part of Northumberland County, particularly south of the coal basin, dug wells supply nearly all the farms.

Analyses of waters in Montour County

[Parts per million. Numbers at heads of columns refer to corresponding numbers on map and in well table.]

	994	997	1005
Silica (SiO ₂)	---	---	7.2
Iron (Fe)	---	---	.09
Calcium (Ca)	¹ 88	97	30
Magnesium (Mg)	---	40	13
Sodium (Na)	}	}	1.9
Potassium (K)			1.0
Bicarbonate (HCO ₃)	248	340	135
Sulphate (SO ₄)	¹ 175	165	10
Chloride (Cl)	39	5.0	2.1
Nitrate (NO ₃)	.0	.20	6.7
Total dissolved solids	² 514	² 523	152
Total hardness as CaCO ₃	³ 210	² 406	² 128
Date of collection	Sept. 4, 1931	Oct. 30, 1930	Sept. 4, 1931

¹ By turbidity.

² Calculated.

³ Determined.

Analysts: 994, 1005, Margaret D. Foster; 997, L. A. Shinn.

Analyses of waters in Northumberland County

[Parts per million. Numbers at heads of columns refer to corresponding numbers on map and in well table.]

	1010	1032	1044	1056	1096	1098
Silica (SiO ₂)	---	---	---	---	---	15
Iron (Fe)	---	1.2	---	---	---	.12
Calcium (Ca)	91	436	28	80	30	42
Magnesium (Mg)	28	87	6.1	24	4.4	8.2
Sodium (Na)	}	}	}	}	}	3.6
Potassium (K)						.4
Bicarbonate (HCO ₃)	180	169	129	101	98	87
Sulphate (SO ₄)	164	1,266	² 9	88	² 13	67
Chloride (Cl)	19	136	2.0	98	1.0	2.1
Nitrate (NO ₃)	8.7	.50	.40	---	.10	3.0
Total dissolved solids	¹ 422	¹ 2,102	¹ 124	¹ 364	¹ 102	198
Total hardness as CaCO ₃						
(calculated)	342	1,447	95	298	93	139
Date of collection	Oct. 30, 1930	Sept. 4, 1931	Oct. 28, 1930	Oct. 30, 1930	Oct. 28, 1930	Sept. 3, 1931

¹ Calculated.

² By turbidity.

Analysts: 1010, 1044, 1056, 1096, L. A. Shinn; 1032, 1098, Margaret D. Foster.

Public water supplies in Northumberland County derived from ground water

Place and Owner	Source	Geologic source	Storage (gallons)	Average daily consumption	Treatment	Remarks
Dalmatia Dalmatia Water Co., Inc.	5 springs 1 drilled well (auxiliary)	Springs in Hamilton, well in Onondaga	185,000	550 consumers	None	Also supplies 15 fire plugs, silk mill, shirt factory, and knitting mill. See well and analysis, 1096.
Northumberland Northumberland Water Co. (Population 4,483 in 1930)	Stream, ore tunnel, 2 drilled wells (auxiliary)	Cayuga or Clinton	5,000,000	510,000 gallons	Chlorine gas	50 percent used by inhabitants, 25 percent by manufacturers, 25 percent by railroad. Also supplies 30 fire plugs. During summer of 1930 one-third of supply furnished by drilled wells. See wells 1043 and 1044; analysis 1044.
Treverton Treverton Water Co.	1 spring, 1 ore tunnel, 2 drilled wells	Mauch Chunk and Pocono	450,000	250 consumers	None	Also supplies 20 fire plugs. See wells 1078 and 1079.

Drilled wells in Montour County

No.	Location ¹	Owner or tenant	Topographic situation	Altitude above sea level (feet) ²	Depth (feet)	Diameter (inches)	Character of material	Geologic horizon	Depth to which well is cased (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
987	Anthony Twp. White Hall	John Hawes	-----	-----	75	-----	Soft dark "slate"	Portage	20±	25±	large?	D	Dry down to a depth of 70 feet; exact location not known.
988	½ mile south-east (?) of Comly Limestone Twp.	Mrs. L. Snyder	Valley	-----	145	6		Hamilton	30	-----	5±	do	
989	½ mile west of Ottawa	Mr. Courtner	Rolling	-----	50	-----	Limestone	Oriskany	-----	25-30	-----	do	
990	do	D. R. Rischel	do	-----	50±	-----	Cherty sandstone	do	-----	35±	small	do	Water reported to be hard.
991	California	Mr. Crawford	do	-----	135	6	Limestone	Helderberg	-----	40-50	10	do	
992	1½ mile north-east of Limestoneville	Henry Stone	Valley	-----	41	6	do	Cayuga	30	20±	10	do	
993	Limestoneville	Mr. LeVan	do	-----	24	6	do	do	12-13	12	10-15	do	
	Derry Twp.												
994	Washingtonville	Washingtonville Community House	do	-----	230	6	Black limestone	Helderberg	40	25	5	do	Water reported to be hard; see analysis 994; temperature 54°F, September 4, 1931.
995	do	G. Sidel	do	-----	87	6	Limestone	do	30-35	40±	10±	do	
996	Strawberry Ridge	Calvin Shiers	Rolling	-----	80	6	Black slate	Marcellus	-----	35	3±	do	
997	do	Dairymen's Cooperative Association	do	-----	200	6	do	do	-----	20±	25±	I	Water contains hydrogen sulphide and is reported to be hard; see analysis 997; temperature 55°F, October 30, 1930.
	Valley Twp.												
998	2 miles south of Washingtonville	L. S. Huffman	Hillside	-----	100	6	do	Portage	18-20	32	10-15	D	Water struck at depth of 95 feet, rose within 32 feet of the top; small draw-down pumping 10 to 15 gallons a minute.

Liberty Twp.													
999	2½ miles west of Pottsgrove	C. D. Lintner	Saddle	560	72½	6	do	Marcellus (?)	26	12-13	6	do	Draw-down 35 feet pumping 6 gallons a minute continuously; gray rock 65 feet, black slate 7½ feet.
1000	¾ mile south of Mooresburg 1½ miles north-east of Mooresburg	Philadelphia & Reading R. R.	Valley	600	40-50	6	Gray shale and "slate"	Marcellus	14	-----	-----	D W	
1001		C. Wintersteen	Hillside	600	54	6	Dark shale	Portage	20	flows	-----	D	
Mahoning Twp.													
1002	Danville	Mr. Wolf.	do	550	136	6	Limestone	Cayuga	43½	96	1½	do	Soil and loose rock 43 feet, gray sandstone (dry) 82 feet, limestone (water-bearing) 11 feet. Well 1; draw-down 172 feet pumping 26 gallons a minute for 11 hours; wells 1 and 2 together furnish an inadequate water supply. Well 2; draw-down 172 feet pumping 26 gallons a minute for 11 hours; 1½ blocks from well 1. Bedrock overlain by 60 feet of clay and "hardpan"; Draw-down 54 feet pumping 11 gallons a minute for 30 minutes; see analysis 1005; temperature 52°F, September 4, 1931. Small draw-down pumping 21 gallons a minute.
1003	do	Geisinger Hospital	do	540	528	10	Red shale	Bloomsburg	28	68	26	H	
1004	do	do	do	540±	592	10	do	do	28	68	26	do	
1005	do	Universal Industrial Corporation	Valley	520	118	6	Limestone	Tonoloway	60	54	11	I	
1006	Cooper Township 4 miles east of Danville	Stewart Hartman	Saddle	640	102	6	do	Helderberg	26	55	21	D	
1007	Mayberry Twp. Roaring Creek	Mr. Eckman	River terrace	460	88	-----	Red shale	Catskill	10	35	20	do	

¹ If no distance is given well is located in town.

² Generally estimated from nearest contour line or bench mark on topographic map.

³ D—Domestic; D W—Drinking water; H—Hospital; I—Industrial.

Drilled wells in Northumberland County

No.	Location ¹	Owner or tenant	Topographic situation	Altitude above sea level ² (feet)	Depth (feet)	Diameter (inches)	Character of material	Geologic horizon	Depth to which well is cased (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
1008	Delaware Twp. 2½ miles north of Dewart	W. E. Dentler	River terrace Valley	480	87	-----	Dark-gray shale	Hamilton	46	27±	4-6	D	Bedrock overlain by 46 feet of sand and gravel. Water reported to be very hard and to contain considerable hydrogen sulphide. Two wells; yield 4-inch pipe full each; water too hard for boiler use; see analysis 1010; temperature 51°F., Oct 30, 1930.
1009	¼ mile north of Dewart	Dairymen's Cooperative Association		480	465	-----	Limestone(?)	Cayuga	-----	20±	150±	N	
1010	do	Dewart Milk Products Co.		480	210 and 218	6	do	do	-----	75±	large	C	
1011	¾ mile east of Springtown	Bryson estate	Hill	580	120±	6	Limestone	Tonoloway	-----	-----	small	D	Large draw-down.
1012	¾ mile north of Watson-town	George Fairchild	Valley	460	63	-----	Gray shale and limestone	Cayuga	-----	35	5-6	do	Dug 22 feet, drilled 41 feet.
1013	Watsonstown	Watsonstown Door & Sash Co.	do	480	65	6	Limestone	do	35-40	20±	1½	D W	100 feet deep when drilled, later filled up with gray-blue mud; limestone overlain by red shale; bedrock overlain by 85 to 40 feet of sand and gravel.
1014	1 mile south of Watsonstown	Watsonstown Brick Co.	do	480	160	6	Limestone?	do	-----	30	10±	I	Small draw-down pumping 10± gallons a minute; limestone overlain by red shale.
1015	2 miles south of Watson-town	Faro Brick Co.	do	480	90	-----	Red shale	Blooms-burg	26	25-30	5	D	
1016	½ mile north of McEwensville	E. D. Fairchild	do	500	37	6	-----	Cayuga	32	2	4	do	
1017	½ mile north-east of McEwensville	George Wesner	Hillside	540	32	6	Gray "slate"	do	24	flows	6	do	Flows a small quantity of water in wet seasons; yields 6 gallons a minute by pumping in dry seasons; water reported to be hard.
1018	McEwensville	G. Colenberger	do	520	39	6	Soft shale	do	30	-----	small	do	

	Lewis Twp.													
1019	2½ miles north Turbotville	D. R. Rothrock	do	700	128	6	Dark gray rock	Portage	28				do	
1020	Turbotville	Dewart Creamery	Valley	540	108		Limestone	Helder- berg (?)		3-4	15-20	I	Small draw-down during winter; in October 1930 draw-down 30 feet pumping 15 to 20 gallons a minute for 1 hour.	
1021	do	Dairymen's Cooperative Association	do	540	293	8	do	do	32	8-9	25	do	Pumps dry pumping more than 25 gallons a minute.	
1022	do	Berrizi Bros. Silk Mill	Hillside	560	196	6	do	do	30	flows	16	do	Flows a small quantity of water in wet weather; yields 16 gal- lons a minute by pumping; light shale and limestone above 100 feet, limestone below 100 feet; water softened for boiler use.	
	Turbot Twp.													
1023	2 miles north of Milton	Fisk Brick Co.	Valley	460	100	6	Red shale	Blooms- burg	18-20	30-35	5	D W		
1024	1 mile north of Milton	Milton Fair Grounds	do	460	54	6	Limestone	Cayuga		15-20	10	D		
1025	3 miles north- east of Milton	Mr. Presler	do	500	40	6	do	do	24	25±		do		
1026	4 miles north- east of Milton	J. D. Smith	do	540	138±	6	do	do			3-4	do		
1027	1½ miles north- east of Milton		Canyon	520	47	6	Red shale	Blooms- burg	8±		3±	do	Large draw-down pumping 3± gallons a minute; water re- ported to be hard.	
1028	1½ miles east of Milton	Ralph Belford	Hillside	560	100		Limestone	Cayuga		50	6	do	First water at a depth of 75 feet.	
1029	Milton	Hertz Bros.	Valley	480	152	6	Green shale	do	43½		20	I	Bedrock overlain by 43½ feet of sand.	
1030	do	Milton Ice Co.	do	500	328	8	Red shale	do	30	22-23	75	do	Draw-down 48 feet pumping 75 gallons a minute; limestone 110 feet, red shale 218 feet.	
1031	do	Pleasant Valley Creamery	do	480	602	8	Blue lime- stone	do	30	19	125	do	Considerable water obtained from a solution channel at a depth of 350 feet.	
1032	do	Dairymen's Cooperative Association	Hillside	480	240	8	Limestone	do	30-40	10	90	do	Draw-down 30 feet pumping 90 gallons a minute for a long period; bedrock overlain by 30 to 40 feet of sand and gravel; limestone overlain by red and green shale; see an- alysis 1032; temperature 54° F., Sept. 4, 1931.	

Drilled wells in Northumberland County—Continued

No.	Location ¹	Owner or tenant	Topographic situation	Altitude above sea level ² (feet)	Depth (feet)	Diameter (inches)	Character of material	Geologic horizon	Depth to which well is cased (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of waters ³	Remarks
1033	East Chillisquaque Twp. Pottsgrove	-----	Hillside	500	90	6	Black "slate"	Hamilton	20-22	-----	small	D	
1034	West Chillisquaque Twp. 1½ miles south of Milton	Smith & Limick	River terrace	460	106	6	do	Marcellus	30	9	5	do	Bedrock overlain by 30 feet of sand.
1035	2 miles south of Milton	Woods Mitter	do	460	197	6	do	do	30	17	6½	do	Pumps dry pumping 6½ gallons a minute for ½ hour; 50 pounds charge of dynamite discharged at the bottom of the well without much increase in yield.
1036	¾ mile south-east of Montandon	S. W. Riechenbach	Valley	460	63	6	-----	Helderberg	-----	30	-----	do	Water reported to be soft; dug 30 feet, drilled to 63 feet.
1037	Chillisquaque	State Nursery	River terrace	440	100	6	Dark gray "rock"	Cayuga (?)	35±	-----	small	do	Dug 30 feet, drilled to 100 feet; dark-gray rock overlain by brown shale, which is overlain by 35± feet of sand and gravel.
1038	Point Twp. 2½ miles north-west of Northumberland	Mertz Bros. Nursery	Hillside	460	153	6	Black "slate"	Helderberg (?)	37	30	5	do	"Loam" containing cobbles 37 feet; shale, limestone (2 gallons a minute at a depth of 70 feet); black "slate" (water struck at 148 feet, rose within 30 feet of the surface); water reported to be hard.

1039	$2\frac{1}{2}$ miles north of Northumberland	Harvey Geise	Canyon	720	110	-----	Limestone	Tonoloway	80	80±	small	do	Pumped dry if pumped excessively during September 1930; a limestone sink hole is located nearby; possibly the 80 feet of casing was used to seal off dry solution channels.
1040	$\frac{1}{2}$ mile northwest of Northumberland	Point Township School	do	480	291	6	Gray shale	Portage (?)	-----	20±	$6\frac{1}{2}$	do	Draw-down 100 feet pumping $6\frac{1}{2}$ gallons a minute.
1041	Northumberland	Ray Johnson	Valley	480	100	-----	do	Catskill	30	30±	10	do	Bedrock overlain by 30 feet of sand and gravel.
1042	1 mile north of Northumberland	Mrs. G. M. Epler	Ridge	760	60	6	Shale	Portage	-----	22±	Mod- erate	do	Never fails, although a nearby well 110 feet deep fails during every dry spell; dug 30 feet, drilled to 60 feet; water reported to be medium hard.
1043	$3\frac{3}{4}$ miles northeast of Northumberland	Northumberland Water Co.	Hillside	700±	600	6	Green sandstone?	Cayuga or Clinton	-----	flows	71	P S	Well 1; flows during wet seasons; pumps 71 gallons a minute continuously; see log.
1044	do	do	do	650±	644	6	Dark sandstone?	Bloomsburg	-----	Shallow	71	do	Well 2; 500± yards south of well 1; large draw-down pumping 71 gallons a minute continuously; see log; see analysis 1044; temperature 53° F., Oct. 28, 1930.
1045	$\frac{3}{4}$ mile north of Cameron	Greenough Farm	do	580±	204	-----	Limestone or gray shale?	Heldberg(?)	22	flows	15	D	Flows 15 gallons a minute; water level 10 feet above the ground surface.
1046	Chulasky	Norman Webb	River terrace	460	87	6	Red sandstone	Cayuga	81	36	-----	do	Bedrock overlain by 81 feet of clay, "quicksand", sand, and gravel.
	Gearhart Twp.												
1047	Riverside	Clarence Hoover	do	480	96	6	Limestone(?)	Heldberg	30	40±	14	do	Small draw-down pumping 14 gallons a minute.
1048	do	Sheffert Creamery Co.	do	460	132	6	Limestone	do	45	56	large	I	Small draw-down; bedrock overlain by 45 feet of sand and gravel.
1049	do	Woodlawn Farm Dairy	do	460	145	6	Black "slate"	Marcellus	45	44	50	do	Small draw-down pumping 50 gallons a minute; bedrock overlain by 45 feet of sand and gravel.
	Rush Twp.												
1050	$\frac{1}{4}$ mile southeast of Union Corner	Ambrose Hensel	Hillside	1,000	120	6	Hard gray sandstone	Portage	18-20	50	5	D	

Drilled wells in Northumberland County—Continued

No.	Location ¹	Owner or tenant	Topographic situation	Altitude above sea level ² (feet)	Depth (feet)	Diameter (inches)	Character of material	Geologic horizon	Depth to which well is cased (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
1051	Kline Grove	Jacob Ryan	Valley	620	36	6	Red sand-stone	Catskill	14	flows	18	D	Flows ³² gallon a minute; water level 5 feet above ground surface; pumps 18 gallons a minute; red sandstone overlain by red shale.
	Upper Augusta Twp.												
1052	$\frac{1}{2}$ mile north of Sunbury	A. W. Pontius	Island	440	150	6	Red shale	do	45	34	28	do	Small draw-down pumping 28 gallons a minute.
1053	do	Airport	do	440	84	6	Red sand-stone	do	39	18	20±	do	Cased through 39 feet of sand and gravel; some water in gravel.
1054	Sunbury	Sunbury Milk Products Co. Engle's Creamery	River terrace	440	190	8	-----	Portage	40	48	40	I	Small draw-down pumping 40 gallons a minute.
1055	do	do	do	440	260	8	Gray shale	do	10	50	10-15	N	Large draw-down pumping 10 to 15 gallons a minute.
1056	do	do	do	440	160	6	do	do	25	50±	75±	I	Large draw-down pumping 75± gallons a minute continuously; pumping this well lowers water level in the abandoned wells; see analysis 1056; temperature 54° F., Oct. 30, 1930.
1057	do	J. S. Cline	do	440	22	24	Gravel	Glacial drift	22	20	-----	N	Dug well, depth to water level measured Nov. 3, 1931. See pl. 4.
1058	1 mile east of Sunbury	Milk station	Valley	480	70	6	Blue black shale	Portage	20+	10-12	30	I	Small draw-down pumping 30 gallons a minute; dry to depth of 68 feet, then water rose to a point 10 or 12 feet below the surface.
	Rockefeller Twp.												
1059	Augustaville	H. N. Wilkinson	do	640	40	-----	Black slate	do	10-12	6	2-3	D	
1060	Seven Points	Mr. Dinklelacker	do	640	41	6	-----	do		24	large?	do	Dug 28 feet, drilled to 41 feet.

Shamokin Twp.													
1061	Snydertown	John Broschous	do	520	52	6	-----	do	20	20±	10±	do	Depth to water level and yield measured in 1928
1062	do	do	do	520	23	24	Black shale	do	23	4½-16	-----	do	Dug well; depth to water level 16.4 feet Sept. 16, 1930; 4.5 feet Sept. 16, 1931; a dug well 18 feet deep 100 feet east was reported to be dry.
1063	do	Coal-washing plant	do	500	50	6	do	do	6-7	3	25±	I	Small draw-down pumping more than 25 gallons a minute.
1064	Deibler	do	do	500	80-100	-----	do	do	18-22	flows	large	do	Flows 20 gallons a minute; yields more by pumping; out of 4 drilled wells at Deibler, the driller reports that two flowed and the depth to water level in the other two was 1½ feet below the surface. Pumps dry rapidly.
1065	1 mile west of Stonington	Harry Leister	Ridge	780	78	6	Gray sand-stone	Hamilton	-----	63±	3-4	D	
1066	Stonington	Will Wilhour	Valley	580	50	6	Hard gray sandstone	do	Shallow	20	-----	D	
1067	Paxinos	-----	do	580	60-70	6	Shale	Portage	25	25±	Moderate	do	Bedrock overlain by 25 feet of sand and gravel.
1068	2½ miles south-west of Paxinos	E. W. Swank	Hillside	800	265	6	Hard black "rock"	do	-----	40	do	do	
Ralpho Twp.													
1069	1½ miles south-west of Elysburg	Alvin Swank	Knoll	720	108	6	Black shale	do	2-3	30+	3-5	do	Formerly pumped dry pumping more than 5 gallons a minute; during summer of 1930 pumped dry when pumping more than 3 gallons a minute.
1070	Elysburg	Silk Mill	Valley	600	47	6	Black slate	do	2-3	-----	-----	I	Dug 12 feet, drilled to 47 feet; water has an odor of hydrogen sulphide.
1071	do	D. K. Leisering	do	600	60	6	do	do	-----	flows	Moderate	D	Water has odor of hydrogen sulphide.
1072	Weigh Scales	J. Geisinger	do	660	42	6	-----	Pocono or Catskill	18-20	6-8	2-3	do	
Coal Twp.													
1073	Uniontown	Mr. Monry	do	680	101	6	Red shale and sand-stone	Mauch Chunk	18	35	20+	I	Draw-down 25 feet pumping 20 gallons a minute continuously.

Drilled wells in Northumberland County—Continued

No.	Location ¹	Owner or tenant	Topographic situation	Altitude above sea level ² (feet)	Depth (feet)	Diameter (inches)	Character of material	Geologic horizon	Depth to which well is cased (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
1074	$\frac{1}{4}$ mile west of Bear Gap	Bear Gap Water Co.	Valley	900	745	10	Conglomerate and green sandstone?	Pocono (?)	28	2	120	N	Abandoned in 1929 because pumping dried up several large springs; draw-down 340 feet pumping 400 to 500 gallons a minute for 15 minutes; working pumping rate 120 gallons a minute; see log.
1075	Bear Gap	do	do	900	1,250	10	Conglomerate and dark sandstone(?)	Pocono	21	flows		P S	Flows 5 gallons a minute into stream supply; see log. Would have large yield if pumped.
	Mount Carmel Twp.												
1076	$\frac{1}{2}$ mile south of Mount Carmel	Mount Carmel Water Co.	Hillside	1,400	1,176	8 $\frac{1}{4}$	Green and gray sandstone(?)	Pottsville or Mauch Chunk	400	Shallow		N	Mar. 31, 1910, well reported to have flowed 120 gallons a minute; mining operations lowered water level until it flowed very little in 1928 and stopped flowing shortly after 1928; well would have large yield if pumped but has been abandoned through an agreement to buy water from Bear Gap Water Co.; cased through lowest coal at 400 feet; see log.
	East Cameron Twp.												
1077	1 mile south-east of Gowan City	Clayton Stone	do	940	99	6	Soft red shale	Mauch Chunk	24	32		D	

1078	Zerbe Twp. 1/4 mile north-east of Trevorton	Trevorton Water Co.	do	1,100±	280	-----	Conglomerate	Pocono	-----	flows	5+	P S	Diamond-drilled 280 feet at an angle of 45° into the mountain from the end of a 150-foot tunnel; 3 holes drilled horizontally from the end of the tunnel were dry.
1079	Trevorton	do	Valley	800±	140	6	White sandstone	Mauch Chunk	80	do	240	do	Two wells 8 feet apart, same depth; one flows 5 gallons a minute; the other flows 15 gallons a minute; small draw-down pumping each well at 240 gallons a minute; cased through 80 feet of red shale and sand.
1080	do Little Mahanoy Twp.	Trevorton High School	Hillside	920	190	8	Red shale	do	54	20	40	D	Draw-down 15 feet pumping 40 gallons a minute continuously.
1081	1/2 mile south of Raker Jackson Twp.	Ed. Raker	Valley	580	102	6	do	do	30-35	42±	1	do	
1082	Herndon	Mr. Snyder	do	400	92	6	-----	Catskill	40±	47	1/2	do	Pumps dry when pumping more than 1/2 gallon a minute.
1083	1/4 mile south of Herndon	Herndon Textile Co.	Hillside	440	137	6	-----	do	30±	30±	50±	I	Depth to water level 30 feet in 1928; water reported to be soft.
1084	1/2 mile south-west of Herndon Washington Twp.	Charles Regor	Valley	400	41	6	Gray "rock"	do	30	-----	15±	D	Small draw-down pumping 15± gallons a minute.
1085	1 mile east of Red Cross	Morris Rebuck	do	500	65	6	-----	do	25-30	-----	-----	do	
1086	1 1/2 miles south of Rebuck Upper Mahanoy Twp.	Rufus Schwaben	Hillside	900	50	6	Gray sandstone and shale	Portage	22	27	1	do	Large draw-down pumping more than 1 gallon a minute.
1087	Greenbrier	Charles Reed	Valley	700	47	6	Hard gray shale	Catskill	8	6	1	do	Pumps dry pumping 1 gallon a minute for a long period; water reported to be soft.

Drilled wells in Northumberland County—Continued

No.	Location ¹	Owner or tenant	Topographic situation	Altitude above sea level ² (feet)	Depth (feet)	Diameter (inches)	Character of material	Geologic horizon	Depth to which well is cased (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
1088	1 mile north-west of Leek Hill	-----	Hillside	980	88	-----	Red sandstone	Catskill	-----	-----	1+	D	Brown sandstone 55 feet, red shale 15 feet, red sandstone 18 feet.
1089	$\frac{1}{2}$ mile west of Leek Hill	Louis Snyder	do	800	-----	6	Red sandstone and shale	do	shallow	23	8-10	do	
1090	$\frac{1}{4}$ mile west of Leek Hill	Mr. Schoffstall	do	800	32	6	Hard gray "slate"?	do	-----	12	5±	do	Dug 16 feet, drilled to 32 feet; water reported to be soft.
1091	1 mile north-west of Rough and Ready Jordan Twp.	Ellsworth Klinger	Valley	700	54	6	Sandstone	Portage	20	15	small	do	
1092	1 mile south-east of Bull Run	Harry Grim	Hillside	640	48	-----	Limestone	Heldenberg	14	-----	-----	do	Adequate supply.
1093	do	W. A. Schlagel	Valley	620	48	6	do	do	shallow	18	-----	do	
1094	Lower Mahanoy Twp. Hickory Corners	George F. Byerly	Hillside	700	40	-----	do	Onondaga (?)	-----	20±	1	do	Pumps dry in 10 minutes pumping slightly more than 1 gallon a minute.
1095	$\frac{1}{2}$ miles north-east of Dalmatia	Oscar Schlagel	Valley	420	18	6	Hard white sandstone	Hamilton	-----	16	8	do	

1096	$\frac{1}{2}$ mile south-east of Dalmatia	Dalmatia Water Co.	Hillside	600 \pm	130	S	Soft "rock"	Onondaga (?)	50 \pm	flows	Mod- erate	P S	Flows a small amount in wet weather; 8 \pm feet to water level in September 1930; yields 10 \pm gallons a minute by siphon; water encountered in soft "rock" below hard black "rock"; see analysis 1096; temperature 54° F., Oct. 28, 1930.
1097	Dalmatia	C. H. Brosius	Valley	440	88	6	Limestone	Cayuga	50	38 \pm	5 \pm	D	See analysis 1098; temperature 53° F., Sept. 3, 1931. Shale 40 feet, sandstone 40 feet, sandy shale 13 $\frac{1}{2}$ feet, adequate supply. Pumps dry in half an hour.
1098	2 miles south-west of Dalmatia	Susquehanna Stone Co.	do	400	101	6	Hard gray sandstone	Hamilton	5-6	7 \pm	20	I	
1099	$\frac{3}{4}$ mile north of Malta	C. H. Witmer	Hillside	700	93 $\frac{1}{2}$	6	Sandy shale	Portage	-----	53 \pm	-----	D	
1100	$\frac{1}{4}$ mile east of Malta	C. E. Witmer	do	520	117	6	Red sandstone and shale	Catskill	-----	74	1 $\frac{1}{2}$	do	
1101	$\frac{3}{4}$ mile west of Malta	W. A. Martz	do	540	90	6	-----	Portage (?)	-----	40 \pm	3-4	do	

¹ If no distance is given well is in town.

² Generally estimated from nearest contour line or bench mark on topographic map.

³ C—Cooling; D—Domestic; DW—Drinking water; H—Hospital; I—Industrial; N—None; PS—Public supply.

Driller's logs of Northumberland Water Co.'s wells, 3¾ miles northeast of Northumberland

[Well 1043, p. 211 and fig. 13]		[Well 1044, p. 211 and fig. 13]	
Soil	0- 14	Soil	0- 40
Shale, red	14- 52	Shale, red	40- 60
Soapstone (?)	52- 64	Sandstone, red	60-257
Sandstone, red	64-101	Sandstone, green	257-269
Limestone	101-108	Sandstone, red	269-308
Sandstone, red	108-122	Sandstone, green	308-324
Limestone	122-160	Sandstone, red	324-328
Slate	160-460	Sandstone, green	328-335
Sandstone, green	460-600	Sandstone, dark	335-357
		Sandstone, green	357-362
		Sandstone, dark	362-644

Driller's log of Bear Gap Water Co.'s well ¼ mile west of Bear Gap

[Well 1074 p. 214 and fig. 13]

Sand and gravel	0- 13	Sandstone, gray	302-308
Shale, red	13- 50	Sandstone, green	308-318
Sandstone, gray	50- 60	Conglomerate	318-324
Shale, red	60- 80	Sandstone, green	324-330
Limestone	80- 82	Limestone	330-337
Shale, red	82-103	Sandstone, gray	337-342
Sandstone, brown	103-132	Shale, red	342-375
Sandstone, gray	132-136	Conglomerate, fine-grained	375-424
Sandstone, brown	136-150	Limestone	424-439
Shale, red	150-164	Sandstone, gray	439-485
Sandstone, brown	164-175	Shale, red	485-505
Sandstone, gray	175-205	Sandstone, red	505-563
Shale, green	205-220	Sandstone, green	563-718
Shale, red	220-282	Shale, red	718-734
Shale, green	282-297	Conglomerate, fine	734-745
Shale, red	297-302		

Driller's log of Bear Gap Water Co.'s well at Bear Gap

[Well 1075, p. 214 and fig. 13]

	Feet		Feet
Clay and gravel	0- 16	Limestone	421-426
Shale, red	16- 90	Sandstone, green	426-480
Sandstone, red	90-190	Sandstone, red	480-498
Sandstone, green	190-207	Shale, red	498-508
Shale, red	207-252	Sandstone, red	508-530
Sandstone, red	252-271	Sandstone, green	530-777
Sandstone, green	271-308	Conglomerate, fine	777-901
Conglomerate, fine	308-322	Sandstone, dark	901-915
Shale, red	322-354	Conglomerate, fine	915-1214
Conglomerate, fine	354-421	Sandstone, dark	1214-1250

*Driller's log of Mount Carmel Water Co.'s well half a mile south of
Mount Carmel*

[Well 1076, p. 214 and fig. 13]

Soil	0- 11	Sandstone, gray	748- 771
Conglomerate	11- 49	Sandstone, green	771- 798
Sandstone, gray	49- 97	Sandstone, light	798- 846
Sandstone, light	97- 112	Shale, red	846- 893
Sandstone, gray	112- 299	Conglomerate, green ...	893- 907
Sandstone, dark	299- 305	Shale, red	907- 926
Sandstone, dark	305- 413	Sandstone, light	926- 942
Coal	413- 420	Sandstone, gray	942- 976
Sandstone, gray	420- 451	Sandstone, light	976-1028
Sandstone, light	451- 473	Shale, red	1028-1086
Conglomerate	473- 508	Sandstone, light	1086-1091
Sandstone, gray	508- 558	Shale, red	1091-1111
Conglomerate	558- 586	Sandstone, green	1111-1118
Sandstone, gray	586- 618	Shale, red	1118-1176
Conglomerate	618- 748		

PIKE COUNTY

GENERAL FEATURES

[Area 544 square miles. Population 7,483]

Pike County is the easternmost county in northeastern Pennsylvania and is bounded by New York on the northeast and New Jersey on the southeast. With only 13.8 inhabitants to the square mile, it is the most sparsely populated county in northeastern Pennsylvania, and much of the county is densely forested. Matamoras, with a population of 1,784, is the only borough in the county having 1,000 or more inhabitants. There is very little development of any kind in Pike County, and parts of the county have been open to automobile travel only in recent years. In 1930 there were only 528 farms in Pike County, and in 1929 there were 10 manufacturing establishments whose annual products were valued at \$5,000 or more each. Camps and summer resorts are numerous in Pike County along Delaware River and near the numerous lakes and waterfalls.

SURFACE FEATURES

The highest point in Pike County is High Knob, in the southwestern part of Blooming Grove Township, which is 2,062 feet above sea level. The lowest point is on Delaware River where it leaves the county, at an altitude of 320 feet. The maximum relief is therefore 1,742 feet, but locally the greatest relief occurs along the Delaware, where the steep cliffs in many places tower 600 feet above the river. Pike County is largely a high rolling forested plateau sloping from 1,800 or 1,900 feet down to about 900 or 1,000 feet where it terminates abruptly at the cliffs along the Delaware. This plateau extends southward into Monroe County to form the high Pocono Mountains.

Pike County is drained entirely by Delaware River, which forms its eastern boundary. The larger tributaries are Lackawaxen River, Shohola Creek, and Bushkill Creek. In flowing a distance of 67 miles between Narrowsburg, N. Y., and Deckers Ferry, Pa., Delaware River drops 360 feet—a gradient of 5.4 feet to the mile.

GEOLOGY AND GROUND WATER

GENERAL SECTION

Pike County was entirely covered by ice during the last glacial stage. The prevailing direction of ice movement, as determined by striae, was about S.30°W. Thick deposits of glacial drift cover the county in most places, and there are numerous lakes and waterfalls which have been formed by the damming of preglacial streams. Delaware River flows over a bedrock channel along the Wayne County boundary at least as far south as Narrowsburg, where the rocks are well exposed. Along

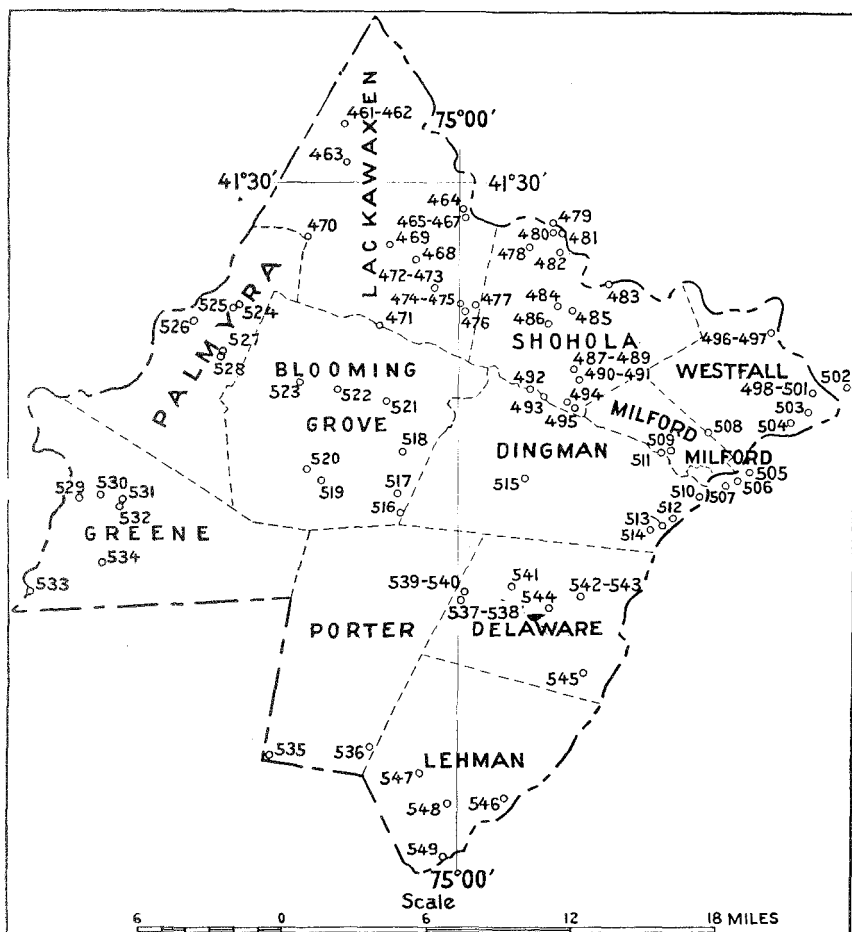


Figure 14. Map of Pike County showing location of water wells

most of the Pike County boundary, however, the Delaware flows over a buried valley filled with glacial outwash. Well-defined terraces may be seen along the Delaware in many places. In the vicinity of Matamoras there are three terraces, the highest of which is about 100 feet above the level of the river. At Milford the lower terraces have been removed on the Pennsylvania side, and a steep bluff rises from the river to the top of the third terrace, 100 feet above, on which the borough of Milford is situated.

The rock formations exposed in Pike County range from the Honesdale sandstone of the Catskill group down to the base of the Onondaga formation. The youngest member, the Honesdale, is exposed only in the westernmost corner of the county. The Catskill continental group crops out over most of the county, except for a strip about 3 miles wide along Delaware River, where the Portage group, Hamilton formation, and Marcellus shale crop out. The Onondaga formation lies below the Marcellus and crops out at the tristate monument and on the east bank of the Delaware in New Jersey.

Generalized section for Pike County

Geologic unit	Maximum thickness exposed (feet)	Character of rocks	Ground-water conditions
Glacial drift (Wisconsin)	300±	Drift (till and outwash) consisting of clay, sand, "quick-sand, and gravel.	Yields small supplies of potable water to numerous dug wells and springs and to a few drilled wells.
Catskill group	2,250±	Cross-bedded gray and green sandstone, red shale, and some greenish gray shale. <i>Contains fish and plant remains.</i>	Supplies nearly all wells in county with adequate water of good quality.
Portage group	1,500±	Hard bluish-gray thin-bedded sandstone, blue sandy shale, and dark sandy fossiliferous shale.	Sandstone yields moderate supplies but shale yields very small supplies. Water reported to be of good quality.
Hamilton formation	1,500±	Limestone 30 feet, bluish-gray sandstone and sandy "slate"	Sandstone yields moderate to large supplies of potable water; shale yields small to moderate supplies of potable water.
Marcellus shale	800	Bluish-gray and bluish-black sandy shale. Dark-gray flinty limestone.	Yields small to moderate supplies of potable water.
Onondaga formation	¹ 250		Wells penetrating solution channels yield large supplies; those encountering dense limestone yield small supplies. Water reported hard.

¹ Exposed in Pike County only at tristate monument but underlies eastern margin of county.

STRUCTURE

The geologic structure of Pike County is relatively simple and is similar to that of Wayne and Susquehanna Counties. At the Wayne County line the rocks are horizontal, but farther south along Delaware River the rocks dip 5°—8°N. No major folds occur in the county, but there are a few minor folds of local extent, such as the Lackawaxen anticline and the Shohola syncline, which cross Delaware River in a northeasterly direction. The Pocono anticline traverses Porter and Delaware Townships.

WATER-BEARING FORMATIONS

[See pp. 41-59 for further description]

Glacial drift.—The glacial drift covering the high plateau of Pike County ranges in thickness from a few inches to about 300 feet. A drilled well near Blooming Grove (well 522) obtains about 10 gallons a minute from drift at a depth of 260 feet. The drift furnishes small supplies of water to many dug wells and is the source of many small springs. Relatively few drilled wells were reported to end in the drift, perhaps because in most places the drift consists largely of clay or of "quicksand" that flows into the well. A few open-finished drilled wells obtain water from lenses of water-bearing gravel, but in most places the drillers case off the drift and extend the hole down into the bedrock. Unless the drill hole extends far enough into the bedrock to encounter a water-bearing stratum, the fractured bedrock may serve merely as a well screen for the water in the drift. The use of well screens or strainers would insure larger supplies of water and would prevent "sanding."

The glacial outwash deposits along Delaware River yield small supplies of water to a few open-finished drilled wells, but no attempts are known to have been made to obtain large supplies of water by means of well screens. Records of wells drilled along the river show that in many places the outwash material consists largely of sand and "quicksand" with very little water-bearing gravel, and it is doubtful if large supplies could be developed from material of this type. The thickness of the glacial outwash obtained from well records along Delaware River is as follows: Lackawaxen, 112 feet; Shohola, 135 feet; Millrift, 100 feet; Port Jervis, N. Y., 113 feet; Milford, 160 and 187 feet; Egypt Mills 170 feet. A drilled well near Milford (well 510) obtains a small domestic supply of potable water from a bed of gravel 19 feet thick overlain by 141 feet of "quicksand." As this well has a surface altitude of 400 feet, which is 100 feet below the top of the highest terrace, the total thickness of the outwash material at this point is more than 260 feet. A similar computation for a well 2 miles southwest of Milford shows a total thickness of outwash material of more than 300 feet.

Catskill continental group.—With the exception of a narrow strip along Delaware River, Pike County is entirely underlain by rocks of the Catskill continental group. The Catskill in Pike County is represented by the five lower members, the Analomink, Delaware River, Shohola, Damascus and Honesdale. The overlying members crop out to the northwest in Wayne County.

The Catskill contains numerous water-bearing sandstones, which in most places can be tapped by wells of moderate depth. The water occurs chiefly in joints in the more massive sandstones and in fractures and bedding planes in the thin-bedded flagstones. The thin-bedded Delaware flagstones are considered by the drillers to be exceptionally good water-bearing rocks. All the wells in the Catskill for which records were obtained were domestic wells, so that the maximum yield obtainable is not known. Most of the wells yield from 5 to 25 gallons a minute, but some were reported to yield as much as 100 gallons a minute on test. The water from the upper part of the Catskill is very soft and low in dissolved mineral matter. That from the lower part is generally of very good quality but in a few places may contain somewhat more dissolved mineral matter than waters from the upper part.

Portage group.—The Portage group crops out in a narrow strip paralleling Delaware River and lying near the edge of the plateau that terminates at the river. The Portage is composed of hard bluish-gray thin-bedded sandstone alternating with blue sandy shale, but nearly all the wells of which records were obtained were reported to end in shale, although it is believed that two of the wells (496, 497), reported to yield 30 gallons a minute, probably obtain water from thin-bedded sandstone. One well ending in shale was reported to yield only 1 to 3 gallons a minute. No samples of water were collected from the Portage in this county, but well owners report that the water is of good quality.

Hamilton formation.—The Hamilton formation crops out in a strip about a mile wide parallel to Delaware River and forms the steep cliffs along the river. The limestone that forms the upper 30 feet of the Hamilton consists almost entirely of corals and other calcareous fossils. The remainder of the Hamilton consists of bluish-gray sandy slates and sandstones having a coarse cleavage at an angle of 50°—60° SE. The numerous waterfalls that occur between Milford and Bushkill flow over hard sandstone beds of the Hamilton.

The sandstones of the Hamilton generally yield moderate to large supplies of potable water. In some places the shales appear to be quite impermeable and yield very little water; in others they yield small to moderate supplies of potable water. No wells are definitely known to obtain water from the limestone at the top, but the spongy, readily soluble character of this coral limestone suggests that it may include solution channels containing water.

The three drilled wells of the Matamoras Water Co. (498-500) obtain abundant supplies of water from the Hamilton formation. Although the driller reported limestones in all the wells and cavernous limestone in well 500, it is believed that the material described as limestone in well 500 is calcareous shale. The Onondaga limestone, encountered in well 501, lies about 1,400 feet below the surface, and the limestone of the upper Hamilton crops out a good distance north of the well, so that probably neither of these limestones could have been encountered in the water company's wells. The water in these wells is believed to occur in sandstones and calcareous shales of the Hamilton and in the underlying Marcellus shale.

Marcellus shale.—The Marcellus underlies the Delaware Valley and is largely covered by glacial outwash except for outcrops along the foot of the cliffs. Although the Marcellus consists entirely of sandy shale, it yields 15 to 25 gallons a minute to several wells, but in some wells it yields very little. Well 513 flows a small quantity and is reported to yield 60 gallons a minute by pumping, but a well drilled nearby to a depth of 315 feet was unsuccessful. Well 501 was drilled to a depth of 1,842 feet in search of oil and gas. The log on p. 230 shows that the upper part of the Marcellus yields fresh water and that the lower slaty part yields salt water when encountered at a considerable distance from the outcrop. No salt water occurs in these beds close to the outcrop, however, and the water obtained in all the other wells in the Marcellus is reported to be of good quality.

Onondaga formation.—The cherty limestone member of the Onondaga formation crops out in Pike County only at the tristate monument, but

it crops out just across Delaware River and is likely to be encountered by deeper wells along the Pennsylvania shore. The flint nodules contained in the limestone cause considerable trouble in well drilling.

The water in the cherty limestone member occurs almost exclusively in solution channels and wells that encounter such channels are likely to be strong, whereas weak or dry holes may result if no channels are encountered. Three wells (505-507) obtain water from the Onondaga in New Jersey just across the river from Milford. Two of these wells are reported to yield 100 gallons a minute from solution channels encountered at the bottom, and the water stands almost at the surface. The third well, drilled only to a depth of 35 feet, encountered no large openings and yields only about 12 gallons a minute. The solution channels apparently do not continue for any great distance down the dip of the beds, as shown by a test boring (well 501) which passed entirely through the Onondaga at a point about 6,800 feet northwest of the outcrop, without obtaining any water. The water in the Onondaga is reported to be hard, as is characteristic of limestone waters.

ARTESIAN CONDITIONS

In most of the drilled wells in Pike County the water rises above the point at which it was first encountered, and in a few wells the water rises to the surface and flows. The flowing wells are scattered, however, and there are no areas where flowing wells can be expected, for the geologic structure of the county is very simple.

QUALITY OF WATER

Analyses of five samples of water collected from wells and springs in Pike County are tabulated on page 223. The bedrock and drift waters are exceptionally soft and contain very small amounts of dissolved mineral matter. It is reported that after well 500 was completed near well 498, there was a sudden influx of iron in the water, which caused considerable trouble in the water mains. This trouble completely disappeared after 2 months, and at present the iron content is too small to be noticeable.

Salt water was reported in the lower part of the Marcellus shale in a deep test well, but no wells drilled primarily for water have reported salt water. Well 501 tapped the Marcellus several thousand feet from its outcrop, where connate water might be expected whereas the wells drilled for water are located on or near the outcrop, where the water has relatively free circulation.

PUBLIC SUPPLIES

There are only four public water supplies in Pike County. The three public water supplies using ground water are tabulated below. Matamoras, the largest borough in the county, obtains its supply from drilled wells; Milford and Bushkill obtain their supplies from springs. Dingmans Ferry is supplied with surface water from Dingmans Creek, which flows through the center of the village. The inhabitants of all the smaller villages are supplied by private wells or springs.

INDUSTRIAL AND DOMESTIC SUPPLIES

So far as is known there are no industrial ground-water supplies in Pike County. There are very few industries in the county, and they are all located in Matamoras or Milford and are supplied with municipal water. Most of the domestic water supplies are obtained from dug or driven wells and springs. Many camps and summer resorts use drilled wells, especially in the village of Greely.

Analyses of waters in Pike County

[Parts per million. Numbers less than 1200 correspond to numbers on map and in table of well data]

	493	498	525	1213 ¹	1214 ¹
Silica (SiO ₂) -----	--	11	--	7.9	--
Iron (Fe) -----	--	.05	--	.05	--
Calcium (Ca) -----	2 ²	20	--	5.6	10 ²
Magnesium (Mg) -----	--	5.5	--	1.5	--
Sodium (Na) -----	7 ³	} 13	--	{ 3.8	{ 6 ³
Potassium (K) -----			--		
		.7	--	.6	
Bicarbonate (HCO ₃) -----	25	78	22	16	45
Sulphate (SO ₄) -----	(⁴)	26	6 ²	8.1	4 ³
Chloride (Cl) -----	1.0	7.0	(⁵)	1.5	2.0
Nitrate (NO ₃) -----	.10	1.8	--	.83	.10
Total dissolved solids -----	25 ³	127	27 ³	37	46 ³
Total hardness as CaCO ₃ (calculated) -----	9 ³	73	--	20	32 ⁶
Date of collection (1930) --	Sept. 20	Sept. 20	Sept. 20	Sept. 20	Sept. 20

¹ 1213. Spring $\frac{1}{2}$ mile northwest of Milford; glacial drift (?); temperature 49° F.

1214. Spring 1 mile northwest of Bushkill; glacial drift; temperature 50° F.

² By turbidity.

³ Calculated.

⁴ Less than 2 parts. ⁵ Less than 1 part. ⁶ Determined.

Analysts: 498, 525, 1213, L. A. Shinn; 493, 1214, K. T. Williams.

Public water supplies in Pike County derived from ground water

Borough and owner	Population, 1930 ¹	Source	Geologic source	Storage (gallons)	Average daily con- sumption	Treatment	Remarks
Bushkill Bushkill Water Co.	-----	2 springs	Glacial drift	10,000	50 con- sumers	None	See analysis 1214.
Matamoras Matamoras Citizens Water Co.	1,784	3 drilled wells	Hamilton and Marcellus	100,000	125,000 gallons	do	See wells 498-500; analysis 498; description of wells, p. 223.
Milford Milford Water Co.	886	5 to 10 springs	Glacial drift	1,350,000	350 con- sumers	do	See analysis 1213.

¹ Figures available only for incorporated places.

Drilled wells in Pike County

No.	Location ¹	Owner or tenant	Topographic situation	Altitude above sea level (feet) ²	Depth (feet)	Diameter (inches)	Character of water-bearing material	Geologic horizon	Depth to which well is cased (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
461	Lackawaxen Township Forest Lake Park	F. Johnson	Hilltop	1,400+	227	6	Soft yellow sandstone	Catskill	-----	120	100	D	Small draw-down pumping 100 gallons a minute; hard blue sandstone 224 feet, soft yellow sandstone 3 feet.
462	do	Elmer Gregor	do	1,400—	164	6	Soft sandstone	do	Shallow	60	10	do	Small draw-down pumping 10 gallons a minute for 1 hour; 300 feet downhill from well 461; hard blue sandstone 120 feet, soft sandstone 44 feet.
463	Tedynskung Lake	F. L. Robinson	Lake shore	1,315	79	6	Gravel	Glacial drift	79	44±	-----	do	Well does not reach bedrock.
464	1 mile north of Lackawaxen	Zane Grey	Valley	610	165	6	Blue flagstones	Catskill	112	-----	-----	do	"Quicksand" and boulders 112 feet, blue flagstones 53 feet.
465	Lackawaxen	Mr. Courtwright	do	620	132	6	do	do	90	-----	-----	do	"Quicksand" 90 feet; blue flagstones 42 feet.
466	do	Anna C. Gregory	do	620	105±	6	-----	do	-----	Flows	6±	do	Flows small quantity; draw-down 80± feet pumping about 6 gallons a minute.
467	do	Smith's store	Hillside	640	75½	6	Gravel	Glacial drift	75½	4	-----	do	Clay and "quicksand" underlain by water-bearing gravel; well does not reach bedrock.
468	1½ miles south of Rowlands	Mr. Ditmart	do	1,140	119	6	Blue sandstone	Catskill	8	24	10	do	
469	1 mile southwest of Rowlands	Mr. Hendrickson	do	720	179	6	do	do	Shallow	16	Small	do	Pumps dry pumping 8 gallons a minute for 1 hour.
470	¾ mile northeast of Kimbles	Mr. Decker	do	830±	126	6	Sandstone	do	do	57	10	do	Small draw-down pumping 10 gallons a minute; blue sandstone 82 feet, green shale 16 feet, soft blue sandstone 10 feet, sandstone (water-bearing) 18 feet.

Drilled wells in Pike County—Continued

No.	Location ¹	Owner or tenant	Topographic situation	Altitude above sea level ² (feet)	Depth (feet)	Diameter (inches)	Character of water-bearing material	Geologic horizon	Depth to which well is cased (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
471	3¼ miles north of Lords Valley	Walter Schmalzer	Hillside	1,320	40	-----	-----	Glacial drift	-----	20±	-----	D	Dug well; water comes nearly to the surface in rainy seasons.
472	1½ miles north-west of Greely	Salvatore Zinnardi	Hilltop	1,298	88	6	-----	Catskill	39	38-39	15	do	Small draw-down pumping 15 gallons a minute; bedrock overlain by 39 feet of clay.
473	1½ miles north-west of Greely	Fred Wendland	do	1,298	134	6	-----	do	75	-----	15	do	Small draw-down pumping 15 gallons a minute; bedrock overlain by 75 feet of clay and sand.
474	Greely	Greenfield's dance hall	Hillside	1,260	60	-----	-----	do	12	25	14	do	
475	do	Frank Shippers	do	1,220	70	6	-----	do	15	16±	15±	do	Small draw-down pumping more than 15 gallons a minute.
476	do	White Pine Hotel	do	1,100	197	-----	Gray sandstone	do	140	-----	17	do	Bedrock overlain by 140 feet of "quicksand."
477	¾ mile north-east of Greely	Mr. Schalp	do	1,220	150	6	Sandstone	do	22	40	10	do	Small draw-down pumping 10 gallons a minute; surface rock 22 feet, blue sandstone 75 feet, red shale 50 feet, sandstone (water bearing) 3 feet.
478	Shohola Twp. 1½ miles south-west of Shohola Highland Twp., N. Y.	Kate Marquardt	do	1,140	100	6	-----	do	1	-----	-----	do	
479	0.4 mile west of Barryville Shohola Twp.	Louis Warshauer	Valley	600	125	6	-----	do	85	-----	50	do	Sometimes flows; draw-down 12 feet pumping 50 gallons a minute; bed rock overlain by 85 feet of clay and sand.
480	Shohola	Shohola Hotel	do	650	157½	-----	-----	do	60-70	80	-----	do	

481	do	Fritz Susserman	do	620±	225	---	-----	do	135	48±	10±	do	Small draw-down pumping more than 10 gallons a minute; bedrock overlain by 135 feet of sand and "quicksand."
482	1 mile south of Shohola	P. Greening	Hillside	800±	155	6	Blue sandstone	do	-----	80	-----	do	
	Lumberland Twp., N. Y.												
483	3 mile east of Handsome Eddy	Thomas S. Rutledge	Valley	550	105	6	do	do	9	28	5	do	
	Shohola Twp.												
484	1½ miles southwest of Parkers Glen	George Haas	Upland	1,220	155	6	-----	do	125	47	15±	do	Bedrock overlain by 125 feet of drift.
485	1 mile southwest of Parkers Glen	Parkers Glen Country Club	Hillside	1,160	255	6	-----	do	110	60	35	do	Bedrock overlain by 110 feet of drift.
486	Walker Lake	T. Egan	do	1,340	163	6	Sandstone	do	80	40	20	do	Bedrock overlain by 80 feet of drift.
487	0.4 mile south of Twin Lakes	Henry Sawyer	Lake shore	1,340	60	6	Blue gray sandstone	do	2-3	1	25	do	Small draw-down pumping 25 gallons a minute.
488	do	Dr. Brown	do	1,340	60	6	do	do	7	12	10	do	Do
489	do	Mrs. Sawyer	do	1,340	65	6	do	do	7	15±	5	do	
490	1 mile south of Twin Lakes	A. J. Michel	do	1,340	198	6	Gray sandstone	do	155	-----	20±	do	
													Bedrock overlain by 155 feet of drift; some water encountered in gravel at 144 feet; small draw-down pumping more than 20 gallons a minute.
491	do	S. Simons	do	1,340	185	6	Sandstone	do	125	30	20±	do	Small draw-down pumping 10 gallons a minute; drift 72 feet, blue sandstone 15 feet, red shale 20 feet, blue sandstone 20 feet, red shale 13 feet.
492	1½ miles southeast of Shohola Falls	Dewey Kingston	Hilltop	1,500±	140	6	Blue sandstone	do	72	30	10	do	
493	2.4 miles southwest of Twin Lakes	Cleveland McKean	do	1,392	118±	6	Red shale	do	101	45±	20-25	do	See analysis 493; temp. 49° F. Sept. 20, 1930, moderate draw-down pumping 20 to 25 gallons a minute for half an hour; bedrock overlain by 101 feet of drift.
494	2 miles south of Twin Lakes	Joe Shields	Saddle	1,420	86	6	-----	do	59	45	5	do	Large draw-down pumping 5 gallons a minute; bedrock overlain by 59 feet of clay.

Drilled wells in Pike County—Continued

No.	Location ¹	Owner or tenant	Topographic situation	Altitude above sea level ² (feet)	Depth (feet)	Diameter (inches)	Character of water-bearing material	Geologic horizon	Depth to which well is cased (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
495	2½ miles south of Twin Lakes	Camp Sangamon	Hillside	1,380	209	6	-----	Catskill	120	-----	35	D	Bedrock overlain by 120 feet of drift.
	Westfall Twp.												
496	Millrift	Mr. Maloney	do	500±	167	6	Shale	Portage	100	45	30	do	Draw-down 15 feet pumping 30 gallons a minute; bedrock overlain by 100 feet of glacial outwash.
497	do	Mr. Hazleton	Valley	492	50	6	do	do	10	10	30	do	Draw-down 15 feet pumping 30 gallons a minute.
498	Matamoras	Matamoras Water Co.	do	440	204	8	Hard sandstone and limestone?	Hamilton and Marcellus	18±	30	100	P S	Well 1; see analysis 498; temp. 49° F., Sept. 20, 1930; see p. 223.
499	do	do	do	440	355	8	do	do	-----	2	100	do	Well 2; 50 feet from well 1; draw-down 28 feet pumping 100 gallons a minute.
500	do	do	do	440	304	-----	Hard sandstone and some limestone?	do	30	30	140	do	Well 3; good water encountered above bedrock at depth of 30 feet; lost water in crevice at 45-50 feet; at 70 feet bit dropped 4 feet through cavern in hard limestone yielding considerable water; yield continued to increase with depth.
501	do	-----		440	1,842	-----	Shale	Marcellus	60	-----	-----	N	Drilled for oil and gas; approximate log, outwash gravel 60 feet, no record 241 feet, shale (water-bearing) 740 feet, bituminous black "slate" (salt water) 330 feet, flinty limestone and grit (Onondaga), and sandstone (Oriskany), all dry, 498 feet; no oil or gas obtained.

	Deerpark Twp., N. Y.												
502	Port Jervis, N. Y.	Joe Menges	do	420±	205	-----	Shale	Marcellus(?)	45	26	20	D	Small draw-down pumping 20 gallons a minute; approximate log, outwash gravel 45 feet, no record 80 feet, limestone 50 feet, shale 30 feet.
	Westfall Twp.												
503	1 mile south of Matamoras	Mr. Renklen	do	420±	170	6	do	Marcellus	38	18	25	do	First water at 160 feet.
504	2 miles south of Matamoras	Mr. Westbrook	do	450±	200	6	do	do	-----	50	2-3	do	
	Montague Twp., N. J.												
505	1.4 miles north- east of Mill- ville, N. J.	-----	do	420	50	6	Limestone	Onondaga	Shallow	1±	100	do	All limestone; cavern at bottom reported to yield 100 gallons a minute with small draw-down; water reported hard.
506	do	Harry Knight	do	460	35	6	-----	do	20	15	12	do	
507	do	-----	do	480	108	6	Limestone	do	Shallow	1±	100	do	All limestone; cavern at bottom reported to yield 100 gallons a minute; water reported to be hard.
	Westfall Twp.												
508	2 miles north of Milford	Thomas Moore	Hilltop	1,160	182	-----	Hard gray sandstone	Hamilton	-----	48	25	do	
	Milford Twp.												
509	1½ miles north- west of Mil- ford	Mr. Simon	Hill	393	88	-----	Shale	Portage	30	20	2	do	
	Dingman Twp.												
510	1½ miles south of Milford	Harold Vandnet	Valley	400	160	6	Outwash gravel	Glacial drift	160	-----	-----	do	Sand and "quicksand" 141 feet, gravel water-bearing 19 feet.
511	1½ miles north- west of Mil- ford	Loverlip "The Grove"	Hillside	540	42	6	Drift	do	42	12	3	do	Large draw-down pumping 3 gallons a minute
512	2 miles south- west of Mil- ford	Martin Bensley	Valley	380	204	-----	-----	Marcellus	187	30	20	do	Moderate draw-down pumping 20 gallons a minute; bedrock overlain by 187 feet of "quicksand."

Drilled wells in Pike County—Continued

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GROUND WATER

No.	Location ¹	Owner or tenant	Topographic situation	Altitude above sea level ² (feet)	Depth (feet)	Diameter (inches)	Character of water-bearing material	Geologic horizon	Depth to which well is cased (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
513	2½ miles south-west of Milford	-----	Hillside	500-600	88	-----	Shale	Marcellus	-----	Flows	60 ⁴	D	Small draw-down pumping 60 gallons a minute; driller reports that a well drilled just below this one penetrated 315 feet of shale without encountering any water.
514	3 miles south-west of Milford	Harold Rider	Hillside	600	314	6	Shale	Hamilton	-----	At surface	Small	do	Pumps dry rapidly.
515	7 miles west of Milford Blooming Grove Township	Mr. Hilliard	Lake-shore	1,327	332±	8	Sandstone	Catskill	70	40-50	100	do	Reported small draw-down pumping 100 gallons a minute; on shore of West Log Tavern Pond.
516	5 miles south of Lords Valley	Camp Hemlock	Valley	1,460	232	-----	Gray sandstone	do	60	40	15	do	Large draw-down pumping 15 gallons a minute; bedrock overlain by 60 feet of glacial drift.
517	4½ miles south of Lords Valley	do	do	1,460	65	6	do	do	18	6	Mod- erate	do	
518	2½ miles south of Lords Valley	do	Hillside	1,460	135	7	do	do	-----	35±	8	do	First water at 90 feet; pumps dry pumping more than 8 gallons a minute.
519	4 miles south-east of Blooming Grove	F. W. Winters	Valley	1,480±	51	6	Sandstone	do	15	28	5	do	Small draw-down pumping 5 gallons a minute.
520	3½ miles south-east of Blooming Grove	Mr. Eckwieler	do	1,440±	55	4	Red shale	do	18	20±	-----	do	
521	1½ miles east of Lords Valley	Mr. Vennie	Hilltop	1,400	115	6	Blue sandstone	do	10	8	30	do	Small draw-down pumping 30 gallons a minute; water at various depths but principal water-bearing bed is near bottom.

522	2½ miles east of Blooming Grove	Blooming Grove Hunting & Fishing Club	Hillside	1,480±	260	6-4½	Drift	Glacial drift	260	130	10	do	Well did not reach bedrock; numerous boulders in the drift gave trouble to the driller; draw-down 45 feet pumping 10 gallons a minute for 8 hours. Bedrock overlain by 136 feet of glacial drift.
523	1½ miles northeast of Blooming Grove Palmyra Township	Julius Maier	do	1,480±	155	6	Red shale	Catskill	136	20±		do	
524	¼ mile north of Tafton	Mr. Cresswell	do	1,240	150	4	-----	do	90	50	15	do	Bedrock overlain by 90 feet of glacial drift.
525	½ mile north of Tafton	The Silver Birches	do	1,220	75	6	-----	do	30	28	6	do	Small draw-down pumping 6 gallons a minute; see analysis 525; temperature 54° F., Sept. 20, 1930.
526	1 mile north of Paupack?	Joe Slocum	Lake-shore	1,200+	116	6	-----	do	80	Flows large		do	Exact location not known.
527	1 mile southeast of Paupack	Kaiser Bros.	do	1,530±	175	6	-----	do		30	20	do	Small draw-down pumping 20 gallons a minute.
528	1 mile southeast of Paupack Greene Twp.	Camp Brooklyn	do	1,530±	82		Sandstone	do	63	10±	3-4	do	Bedrock overlain by 62 feet of "quicksand"; small draw-down pumping 3½ gallons a minute.
529	½ mile south of Greentown	Walter Fowler	Hillside	1,440	52	6	Red shale	do	20	20	10-	do	Large draw-down pumping 10 gallons a minute.
530	1 mile southeast of Greentown	Sam Marsh	Valley	1,400	258	6	Soft sandstone	do	74	100	6	do	Small draw-down pumping 6 gallons a minute; glacial drift (cased) 74 feet, red shale 100 feet, blue sandstone 50 feet, soft sandstone (water-bearing) 34 feet.
531	¾ mile southwest of Lake Paupack	Mr. Riehel	Hillside	1,660	150	6	Soft brown sandstone	do	10	50	10	do	Small draw-down pumping 10 gallons a minute; blue sandstone 100 feet, soft sandstone 20 feet, green shale 10 feet, soft brown rock (water-bearing) 20 feet.
532	1 mile southwest of Lake Paupack	do	do	1,640	155	6	Green shale	do	10	50	10	do	Small draw-down pumping 10 gallons a minute; glacial drift (cased) 10 feet, blue sandstone 100 feet, red shale 20 feet, "slate" 10 feet, green shale (water-bearing) 15 feet.

Drilled wells in Pike County—Continued

No.	Location ¹	Owner or tenant	Topographic situation	Altitude above sea level ² (feet)	Depth (feet)	Diameter (inches)	Character of water-bearing material	Geologic horizon	Depth to which well is cased (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
533	$\frac{1}{2}$ mile north-west of Laanna	C. A. Rowell	Valley	1,660	145	6	-----	Catskill	30	12+	-----	D	Water reported to be soft.
534	1 mile south-east of Panther Porter Twp.	G. Sieg	Hillside	1,800	105	6	Hard conglomerate	do	24	95	10	do	Small draw-down pumping 10 gallons a minute; hard conglomerate rendered drilling difficult.
535	$1\frac{1}{2}$ miles south-east of Millertown School ⁵	Gerhard College	Upland	1,060	47	6	-----	do	Shallow	20	25	do	Small draw-down pumping 25 gallons a minute.
536	3 miles north-west of Forest Park Delaware Twp.	Mishawaka Club	Lakeside	980	50	6	Close grained gray sandstone	do	10	10	40	do	
537	$\frac{3}{4}$ mile south-west of Edgemere	J. Bromly	do	1,300	148	6	Hard conglomerate	do	22	20	100(?)	do	Reported small draw-down pumping 100 gallons a minute.
538	do	do	Hillside	1,400	136	6	do	do	67	33	70	do	
539	$\frac{3}{4}$ mile south-west of Edgemere	do	Hilltop	1,420	260	6	do	do	160	90	50	do	Small draw-down pumping 50 gallons a minute; glacial drift (cased) 160 feet, hard sandstone 60? feet, conglomerate (water-bearing) 40 feet.
540	$\frac{3}{4}$ mile south-west of Edgemere	Edgemere Club	Lakeside	1,300	204	6	do	do	138	50	100(?)	do	Reported small draw-down pumping 100 gallons a minute.
541	$1\frac{1}{2}$ miles east of Edgemere	Camp	do	1,175	112	6	-----	do	60	60	30	do	
542	$2\frac{1}{2}$ miles north-west of Dingmans Ferry	Mr. Body	Hillside	1,000	129	6	Shale	Portage	10	50	1-3	do	Pumps dry pumping 1 to 3 gallons a minute.
543	do	Mr. Smith	Canyon	925	122	6	do	do	10	50	1-3	do	

544	3 miles north-west of Dingmans Ferry	Childs Park	do	980	169	6	Limestone(?)	Hamilton	10	1±	100?	do	Reported small draw-down pumping 100 gallons a minute; water level drops to 8 feet below the surface in dry seasons; cased 10 feet, blue sandstone 100 feet, shale 20 feet, pyrite 3 feet, limestone (?) (water-bearing) 36 feet. Small draw-down pumping more than 20 gallons a minute.
545	2 miles south-west of Dingmans Ferry	Charles Steur	Hilltop	900	82	6	Shale	do	11	15	20+	do	
	Lehman Twp.												
546	Egypt Mills	Egypt Mills Club	Valley	360	170	8	Outwash gravel	Glacial drift	170			do	
547	½ mile north-west of Forest Park	Camp Tamiment	Lakeside	1,150	80	6	Flagstone	Catskill	6-8	40—	15±	do	
548	2 miles north of Bushkill	Mr. Freedman	Hillside	840±	147	6	-----	do	30	8-10	45	do	Small draw-down pumping 12 to 15 gallons a minute; bedrock overlain by 140 feet of "quick-sand."
549	½ mile south-west of Bushkill	Mrs. Schultze	Valley	400±	235	6	Black slate	Marcellus	140	30-40	12-15	do	

¹ If no distance is given well is located in town.

² Generally estimated from nearest contour line or bench mark on topographic map.

³ D—Domestic; PS—Public supply.

⁴ By pumping.

⁵ No towns nearby.

SCHUYLKILL COUNTY

GENERAL FEATURES

[Area 777 square miles. Population 235,505]

Schuylkill County lies along the southern border of the area described in this report and adjoins Lebanon, Berks, and Lehigh Counties to the south. Four of the 20 largest municipalities in the area covered by this report are in Schuylkill County—Pottsville, 24,300; Shenandoah, 21,782; Mahanoy City, 14,784; and Tamaqua, 12,936. The industrial development is centered in the two anthracite fields—the eastern part of the Western Middle field, in the northern part of the county, and the large Southern field, which traverses the center of the county from northeast to southwest. In 1930 there were 67 anthracite mines in the county, and in 1929 there were 263 manufacturing establishments whose annual products were valued at \$5,000 or more each. In the area surrounding the coal fields there were 2,502 farms in 1930.

SURFACE FEATURES

Bears Head, 2,100 feet above sea level, in the west corner of Delano Township, is the highest point in Schuylkill County. Nearly a dozen long, narrow, even-crested ridges in the county range between 1,500 and 1,900 feet above sea level and rise 500 to 1,000 feet above the intervening valley areas. Schuylkill River in the water gap at Port Clinton is 400 feet above sea level, which is the lowest point in the county. The difference of 1,700 feet between the highest and lowest points in the county gives a measure of the maximum relief.

There are five distinct drainage areas in Schuylkill County. The northwestern part is drained by Mahantango Creek and other tributaries of Susquehanna River; the northernmost part is drained by Catawissa Creek, a tributary of the North Branch of the Susquehanna; the southeastern part and several small areas in the northeastern part are drained by Lehigh River; the central and greater part of the county is drained by Schuylkill River; and the southwestern part is drained by Swatara Creek, a tributary of the Susquehanna. Thus there is drainage in five directions.

GEOLOGY AND GROUND WATER

GENERAL SECTION

Schuylkill County lies entirely south of the Wisconsin and Illinoian drift borders. The Jerseyan drift border (see pl. 1) traverses the middle of the county, but in the course of the field work no definite deposits of drift were observed.

The rock formations exposed in Schuylkill County range in age from the post-Pottsville formations, of Pennsylvanian age, down to the Tuscarora sandstone. The youngest formations, the post-Pottsville, comprising the Allegheny formation and part of the Conemaugh formation, crop out in the large Southern anthracite field and part of the Western Middle field. The oldest formation, the Tuscarora, crops out along Kittatinny (Blue) Mountain, which forms the southern boundary of the county.

STRUCTURE

The geologic structure of Schuylkill County is complex. The strata have been sharply folded along northeast axes, and the truncated hard and soft beds now form an intricate system of long, narrow ridges and

Generalized section for Schuylkill County

Geologic unit	Maximum thickness exposed	Description of rock	Ground-water conditions
Post-Pottsville formations	2,506±	Sandstone, conglomerate, shale, fireclay, and about 30 beds of workable coal.	Yields small to large supplies of potable water in some places. Near coal mines water is drained or polluted.
Pottsville formation	1,475±	Chiefly coarse quartz conglomerate, some sandstones and shale, and 3 to 7 workable coal beds in western part.	Yields large supplies of excellent water to wells 350 to 1,000 feet deep. Some flowing wells; very few unsuccessful wells.
Mauch Chunk shale	2,950±	Red shale alternating with red and green sandstone. Some conglomerate near top and gray sandstone near base.	Most important water-bearing formation in county; yields 10 to 30 gallons a minute to shallow domestic wells, 15 to 350 gallons a minute to deep wells; many flowing wells; very good water.
Pocono sandstone	1,600±	Massive coarse hard gray sandstone with some conglomerate and some interstratified bluish or greenish slate.	Unimportant owing to topographic position; no wells observed.
Catskill group	6,000±	Chiefly red shale and shaly sandstone, gray sandstone and shale.	Yields adequate supplies to shallow wells and moderate supplies to deep wells. Water reported to be of good quality.
Portage group	2,200±	Dark shale, thin-bedded sandstone, and black shale.	Yields small supplies of water of good quality to domestic wells.
Hamilton formation	1,500±	Dark-gray shale, dark hard fossiliferous slate, and thin-bedded sandstone.	Sandstone yields adequate domestic supplies of very good water; shale yields small supplies.
Marcellus shale	850±	Black and yellow shale and black slate.	Yields adequate domestic supplies of good water.
Oriskany formation	1½-100±	Dark bluish-gray argillaceous limestone and interbedded calcareous shale.	Unimportant.
Oriskany sandstone	1½-100±	Ranges from 1½ foot bed of conglomerate to thick series of coarse pebbly sandstones.	Unimportant. Very thin in most places, uninhabited where thick.
Heiderberg limestone	absent?		
Cayuga group	1,800±	Bloomsburg red beds; red shale and sandstone and lower olive-green shale; Bos-sardville limestone at top thin or absent.	A good water-bearing formation; yields small to moderately large supplies. Water of very good quality.
Clinton formation	972±	Red and green sandstone, red and olive-green shale, and hard white sandstone.	
Tuscarora sandstone	443	Coarse basal conglomerate, gray and white quartzite and sandstone.	No wells; crop out on high mountain.

valleys. The Carboniferous rocks suffered the most intense folding and are overturned in many places. The Selinsgrove anticline dies out in the northern part of the county and strikes into several synclines of the Eastern Middle basin. South of this is the large Mahanoy basin, comprising half of the Western Middle basin and separated from the Shamokin basin by the Locust Mountain anticline. The most important structural feature economically is the large synclinorium of the Southern field, which occupies the center of the county. This basin consists of a number of smaller connected basins, which become successfully deeper and have steeper sides toward the south. With few exceptions the

north dips are much steeper than the south, and minor folds are overturned in some places. The general strike of the folds is about N.65°—70°E. The basin bifurcates toward the west, and the two sides of the "fishtail" project into Dauphin County.

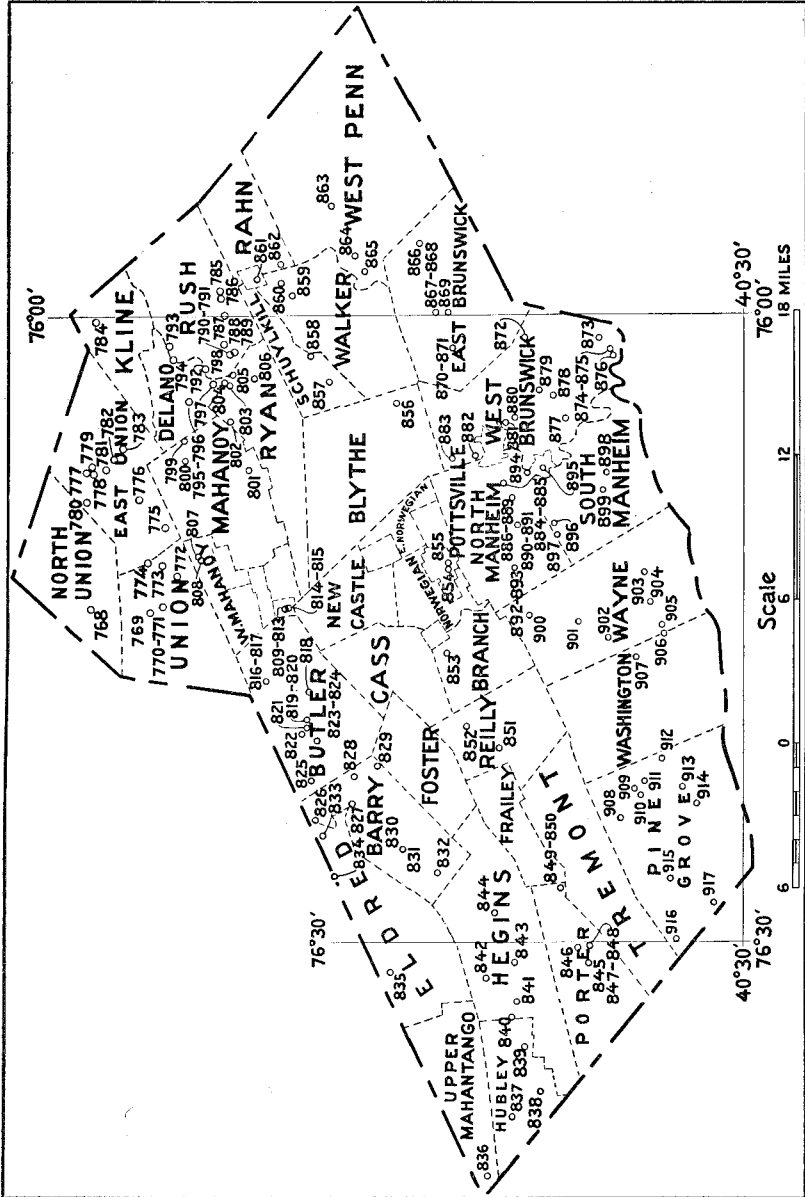


Figure 15. Map of Schuylkill County showing location of water wells

In the southern part of the county the Silurian and Devonian rocks have been folded for some distance on both sides of Schuylkill River. An anticline passing eastward from Cressona exposes the Cayuga group and possibly part of the Clinton formation. A syncline extending west

from Landingville exposes the Catskill group. The Lehighton anticline of Carbon County extends into Schuylkill County as far as Reynolds. The ridge north of Port Clinton is an anticlinal ridge exposing the Clinton formation, and a syncline crosses Schuylkill River just north of Port Clinton exposing the Cayuga group⁹⁶.

WATER-BEARING FORMATIONS

[See pp. 46-68 for further description]

Post-Pottsville formations.—The post-Pottsville formations, including the Allegheny and Conemaugh, attain their greatest thickness in the anthracite region in the Southern anthracite field of Schuylkill County, where they are more than 2,500 feet thick, and in the Mahanoy basin, where they are about 2,000 feet thick. They contain about 20 different workable coal beds and numerous thin seams of coal.

The post-Pottsville formations contain numerous beds of conglomerate, sandstone, slate, and coal, which, owing to severe folding and crushing, contain innumerable fractures that transmit water readily. The depth of mine workings in Schuylkill County averages about 1,000 feet and in some places reaches 1,400 feet, so that in the vicinity of coal mines the strata are drained to great depth by pumping. After 10 years' study, John Bevan⁹⁷, chief engineer of the Philadelphia & Reading Coal & Iron Co., of Pottsville, states that an average of 21 tons of water is pumped out for every ton of coal shipped (not including coal used in boilers by the coal company) and an average of 15 tons of water is pumped out for every ton of material removed from the mines. During the drought of 1930 the mines were unusually dry, and mines that normally yielded about 6,000,000 gallons daily yielded but 1,000,000 gallons. Usually a part of the water pumped is used for washing coal and the rest is discharged into the streams, but in 1930 mine water was greatly in demand, and every drop was needed for washing coal.

In most places in the coal basins the drainage and pollution by the mines make it virtually impossible to obtain potable water by means of drilled wells. Nevertheless, at least 10 wells were observed in use in the Western Middle and Southern coal fields—more than were noted in all the other fields combined. Some wells encounter beds of coal that render the water unfit for drinking, but in other wells the coal apparently does no harm.

Wells in the post-Pottsville formations range in depth from about 40 to 476 feet and reported to yield 1 to 80 gallons a minute. Wells 816 and 817, in Girardville, 120 and 150 feet deep, are reported to yield 75 and 80 gallons a minute from beds of slate. Most of the wells, however, obtain water from beds of sandstone. The Yuenglings Brewery Co., of Pottsville, has two wells 476 feet deep yielding 30 to 55 gallons a minute (see well 855) and also obtains considerable ground water from tunnels driven into the mountain. The water appears to be satisfactory for ordinary purposes. (See analysis 854.)

Pottsville formation.—The Pottsville formation crops out as a high ridge encircling all the coal basins. In most places its strata dip steeply, but it also occupies large flat areas between the two major coal fields.

⁹⁶ See Chance, H. M., Section at the Schuylkill Gap: Pennsylvania Geol. Survey, 2d ser., Rept. G-6, map in pocket, 1882.

⁹⁷ Personal communication.

The Pottsville in the Southern field is noted for its great thickness (1100 to 1475 feet), the coarseness of its materials, and the number and size of the coal beds it contains. At the west end of the Southern field there are seven beds of workable coal including the six Lykens Valley beds, and in the west end of the Western Middle field, where the Pottsville is about 850 feet thick, there are three Lykens Valley beds.

The fractured beds of hard sandstone and conglomerate are very good water producers. The outcrops of the Pottsville are unsuited to agriculture, but several deep wells have been drilled into the Pottsville for public supply, ranging in depth from 350 to 1,000 feet. The known yields range from 65 to 125 gallons a minute, although some of the wells are believed to yield more than this amount. Some of the wells flow all the year; others flow only during wet seasons, and in the rest of the wells the water level lies within 10 to 30 feet of the surface. The yield apparently does not necessarily increase with depth, for well 800 is only 352 feet deep and yields 125 gallons a minute. In wet seasons this well is reported to flow 50 to 75 gallons a minute, but on Sept. 26, 1930, the water stood 15¾ feet below the surface. A few deep wells have been unsuccessful, presumably because they tapped exceptionally "tight" rock devoid of open fractures, but in general the Pottsville may be expected to yield large supplies of good water.

Mauch Chunk shale.—The Mauch Chunk shale has five large areas of outcrop and several small areas separated from one another by coal basins. In the northern part of the county, where its dips are gentle, it forms wide fertile valleys between high ridges of Pocono sandstone and the Pottsville formation. In its southernmost outcrop the beds are nearly vertical and it forms a narrow valley between high ridges.

The Mauch Chunk is perhaps the most important water-bearing formation in Schuylkill County. This is not due alone to the fact that it contains many beds of red and green sandstone which are fractured and transmit water readily, but in large measure to the topographic and geographic position and large areal extent of its outcrops. It not only supplies a great many small farms, but its outcrops surround all the coal basins, in which ground water is relatively scarce, and thus supplies many towns within the basins with water of very good quality. Moreover, it crops out between high ridges and thus receives ample ground-water recharge.

Most of the domestic wells in the Mauch Chunk range in depth from 50 to 120 feet and yield 1 to 30 gallons a minute. A few of these wells are 410 to 455 feet deep and yield 30 gallons a minute, few of them flow, but the water level in most stands 10 to 50 feet below the surface.

Deep wells used for industrial and public supply range in depth from 200 to 1,015 feet and yield 15 to 350 gallons a minute. The average depth of 18 wells is 590 feet and the average yield is about 100 gallons a minute. Some of these wells flow 15 to 50 gallons a minute and would doubtless yield considerably more by pumping. With few exceptions the water level ranges from the surface to 15 feet below. Well 814 is 452 feet deep and yields 350 gallons a minute with a draw-down of 217 feet.

Pocono sandstone.—The Pocono sandstone has five outcrops within the county, all of which are high, even-crested ridges. Little and Catawissa Mountains enter the county and join from the north, Broad Mountain

enters from the east, Line and Mahantango Mountains enter and join from the west, Peters Mountain enters from the southwest, and Second Mountain traverses the county south of the Southern anthracite field. Its topographic position makes the Pocono unimportant as a source of ground water, and no wells were observed along its outcrops.

Catskill continental group.—The Catskill continental group has four outcrops within the county—a small area at the north end, a large valley area at the northwest corner, a belt about 1½ mile wide traversing the county south of and including the southern crest of Second Mountain, and a small synclinal area crossing the Schuylkill River below Landingsville.

Domestic wells in the Catskill are from 50 to 150 feet deep and generally yield 5 to 20 gallons a minute. A few deep wells used for public supply range in depth from 200 to 836 feet and yield 50 to 80 gallons a minute. The water is reported to be of very good quality.

Portage group.—The Portage group is exposed in three different outcrops—a small anticlinal area in the northwest corner, a narrow monoclinal strip traversing the county south of Second Mountain, which bifurcates around the Lehighton anticline to the east; and a closed synclinal belt south of Schuylkill Haven and extending from a point 2½ miles east of Landingville west to Pine Grove.

Wells in the Portage range in depth from 55 to 300 feet and are reported to yield from 2 to 25 gallons a minute. A well (882) one mile northwest of Orwigsburg was drilled in the Portage to a depth of 300 feet in the hope of getting a strong well for public supply, but the well yielded less than 12 gallons a minute and was abandoned. The second well (883) was drilled farther north in the Catskill and was successful. The Portage generally yields water of good quality in Schuylkill County, as indicated by analysis 909, but an odor of hydrogen sulphide is reported in some of the wells.

Hamilton formation.—The outcrops of the Hamilton formation are like those of the Portage group just described, except that it may not reach the surface along Mahoning Creek on the Lehighton anticline. As the Hamilton was not mapped separately in Schuylkill County, it is not always certain whether wells penetrate the Portage, Hamilton or Marcellus.

Sandstone beds in the Hamilton generally yield adequate supplies of water, but the shale yields rather small supplies. The wells range in depth from 47 to 260 feet and are reported to yield 3 to 26 gallons a minute. The strongest well (911) is 260 feet deep and yields 26 gallons a minute continuously. An analysis of the water from this well indicates that except for the presence of an excessive amount of iron, the water is of good quality.

Marcellus shale.—The Marcellus shale underlies the Hamilton formation and its outcrops are similar to those of the Hamilton, just described. The soft yellow and black shales of the Marcellus are used for making brick near Auburn. The Marcellus forms valleys along its strike and therefore good exposures are not everywhere available. Because of the lack of exposures and accurate well logs it is not always possible to tell whether wells end in the Marcellus or in the underlying strata, and some of the geologic horizons are therefore questionable.

The Marcellus generally yields 5 to 15 gallons a minute to wells 60 to 150 feet deep, but one well 131 feet deep (898) is reported to yield only about three quarts a minute. The Marcellus yields water of good quality as indicated by analysis 899.

Onondaga, Oriskany and Helderberg formations.—The Onondaga formation is thin and unimportant and the Helderberg limestone is apparently lacking in Schuylkill County, although Helderberg may be present in the eastern part of the county. The Helderberg limestone shown on plate 1 includes the underlying Bossardville limestone. The Oriskany sandstone crops out in a long, narrow strip along the southern part of the county and swings around a long, narrow anticline and a syncline in the middle of the county south of Second Mountain. It has a tremendous range in thickness within the county. Near Auburn it consists of only 1½ feet of conglomerate resting unconformably on the Bloomsburg red beds, both the Helderberg and the Bossardville being absent. It thickens toward the southwest and is well exposed in a quarry half a mile east of Summit, where it is composed of a thick series of very coarse pebbly sandstone dipping about 45°N. and forming a low rocky ridge.

The Oriskany is unimportant as a source of ground water in Schuylkill County. It is very thin in most places, and where thick it forms a rocky, barren ridge devoid of habitations. The geologic horizon of well 885 was doubtfully assigned to the Oriskany, but no other wells were observed that might obtain water from this formation.

Cayuga group.—The Cayuga group crops out along a wide valley just north of Kittatinny (Blue) Mountain, along an anticline extending from Rauches to a point about 2 miles west of Cressona, and in a syncline near Port Clinton. The uppermost formation, the Bossardville limestone (mapped as Helderberg), is very thin and is lacking altogether in many places, where the Bloomsburg red beds apparently form the top of the Cayuga group.

The Cayuga group (represented in Schuylkill County chiefly by the Bloomsburg red beds) is apparently a good water bearer and is very similar to the Mauch Chunk. However, most of the wells in the Cayuga are relatively shallow domestic wells, so that the Cayuga has not been tested by deep wells, as the Mauch Chunk has.

Wells in the Cayuga range in depth from 80 to 315 feet and are reported to yield from 3 to more than 25 gallons a minute. The upper and lower members consist wholly of shale but are reported to yield small to large supplies of water. The middle member, composed of shale and sandstone, is probably the best water-bearing unit, at least in the vicinity of Port Clinton. Well 875 is 119 feet deep and yields 25 gallons a minute of excellent water from beds of red sandstone (see analysis 875).

Clinton formation.—The Clinton formation makes the main mass of Kittatinny Mountain and probably forms the crest in many places. It is also exposed by a small anticline north of Port Clinton. No habitations or wells were observed on the Clinton outcrops.

Tuscarora sandstone.—The Tuscarora sandstone crops out at or south of the crest of Kittatinny Mountain. It probably enters the county only at the Schuylkill Gap and perhaps along the county line south of Rauches.

The Tuscarora here stands nearly vertical and is unconformable on the nearly horizontal Martinsburg shale. (See pl. 3-B.) The Tuscarora is unimportant as a water-bearing formation because of its topographic position, and no wells were observed penetrating it.

ARTESIAN CONDITIONS

The water level in most of the wells stands considerably above the point where water was first encountered, but only a few of the wells flow. Records were obtained of 15 flowing wells, 9 in the Mauch Chunk formation and 3 in the Pottsville formation. Most of these are close to small coal basins in the northern part of the county or close to the Mahanoy basin. The only flowing well reported in the southern part of the county is at Joliett. Were it not for coal mining and the attendant drainage of the post-Pottsville formations, flowing wells could probably be obtained within the coal basin.

QUALITY OF WATER

The analyses of six samples of water collected in Schuylkill County are tabulated on page 244. The sample from well 809, in the Mauch Chunk formation, contained considerably more dissolved mineral matter than most Mauch Chunk waters. The samples from the dark sandstone or shale of the Portage, Hamilton and Marcellus are low in dissolved solids. Two of them, however, contained sufficient iron to cause a slight precipitate.

The water in the post-Pottsville formations seems to be of good quality where it has not been contaminated by coal mining, as shown by analysis 854. Some of the wells in the coal basins, however, yield water that is unfit for drinking, and as new mines are developed there may be very little potable ground water left in the post-Pottsville beds. It is unlikely that potable water can be obtained from drilled wells close to coal mines, but the chances of obtaining potable water are likely to be good in parts of the basins where mining has not been started.

PUBLIC SUPPLIES

The seven public water supplies using ground water in Schuylkill County are tabulated below. Six of them use ground water exclusively. Orwigsburg derives most of its supply from a small stream, but during the drought of 1930 an auxiliary supply was needed. A well drilled 1 mile northwest of the borough proved to be a failure, and later another well was drilled 2 miles northwest of the borough which was successful and served very satisfactorily during the remainder of the drought. (See wells 882, 883.) It was reported that Gordon and Ringtown are supplied by ground water, but no data were obtained for tabulation.

Pottsville and most of the larger boroughs are situated within the coal basins and are supplied with surface water from small mountain streams. A few of the large surface water supplies have one or more drilled wells, some of which are used occasionally, but the amount of ground water used is insignificant. The Wyoming Valley Water Co., supplying Delano, Delano Junction, Park Place, and Buck Mountain Colliery, has two drilled wells at Park Place and three at Delano (wells 795, 796, 799, 800). The Honeybrook Water Co., supplying McAdoo, Audenried and Kelayres, has two drilled wells near Audenried (well 784). The Shen-

Shenandoah Citizens Water & Gas Co., supplying about half of the borough of Shenandoah, has five auxiliary drilled wells, but very little ground water is used. (See wells 807, 808.) The Schuylkill Haven Water Co. has two auxiliary wells (892-893) which are seldom used. The Pennsylvania Power & Light Co. supplies 20 of its employes' homes with water from a drilled well (911), which also supplies the plant with drinking water.

INDUSTRIAL AND DOMESTIC SUPPLIES

Coal mining is the predominant industry in Schuylkill County, and the mines yield enormous quantities of ground water, which is pumped out and utilized for washing coal. (See p. 239.) Most of the other industries are located in large towns and use municipal water, but a few independent industrial supplies using ground water are listed in the accompanying tables of drilled wells, including a bakery, a dairy, two breweries, ice companies, a textile company, and a rolling mill.

Several large institutions are supplied wholly or in part by drilled wells, including the Immaculate Heart Academy, $1\frac{1}{4}$ miles east of Fountain Springs; the Ashland State Hospital, at Fountain Springs; and the Schuylkill County Almshouse, three-quarters of a mile north of Schuylkill Haven.

Domestic supplies are obtained almost entirely from dug or drilled wells, there being relatively few springs in the county. The scarcity of springs is attributed in part to the fact that the county lies south of the Wisconsin and Illinoian drift borders, for glacial drift supplies most of the springs in counties to the north.

Analyses of waters in Schuylkill County

[Analyst, Margaret D. Foster. Parts per million. Numbers at heads of columns refer to corresponding numbers on map and in well table]

	809	854	875	899	909	911
Silica (SiO ₂)	6.1	8.0	--	--	--	--
Iron (Fe)	.08	.10	--	--	.79	1.4
Calcium (Ca)	43	21	8 ¹	9 ¹	12 ¹	8 ¹
Magnesium (Mg)	6.8	6.8	--	--	--	--
Sodium (Na)	15	7.8	6.3 ²	6.8 ²	7.7 ²	9.2 ²
Potassium (K)	2.0	1.6	--	--	--	--
Bicarbonate (HCO ₃)	56	51	39	24	56	61
Sulphate (SO ₄)	18	6.5	2 ¹	7 ¹	10 ¹	12 ¹
Chloride (Cl)	50	21	1 ¹	1.3 ¹	1.2 ¹	1.0 ¹
Nitrate (NO ₃)	41	22	.35	10	1.6	.0
Total dissolved solids	261	132	37 ²	46 ²	64 ²	69 ²
Total hardness as CaCO ₃ (calculated)	135	80	22	22	42	44
Date of collection (1931)	Sept. 1	Aug. 31	Sept. 2	Sept. 2	Sept. 2	Sept. 2

¹ By turbidity.

² Calculated.

Public water supplies in Schuylkill County derived from ground water

Place	Population 1930 ¹	Owner	Source	Geologic source	Storage (gallons)	Average daily con- sumption	Treatment	Remarks
Frackville	8,034	Mountain City Water Co.	2 springs and 7 drilled wells	Mauch Chunk	500,000	425,000 gallons	Chlorine gas	About 8 percent used by rail- roads, 4 percent by manu- facturers, 88 percent by in- habitants. 57 fire plugs. See wells 800-815; analysis 800.
Hegins and Valley View	-----	Hegins Water Co.	4 springs	do	1,320,000	32,400 gallons	do	About 10 percent used by man- ufacturers, 90 percent by in- habitants. 31 fire plugs.
Hometown	-----	J. M. Ryan	1 drilled flow- ing well	do	-----	12 con- sumers	None	Supplies only a small section of town; rest are private sup- plies. See well 785.
Oneida	-----	Wyoming Valley Water Co.	4 drilled wells, 3 used, flow part time	do	265,000	80,000 gallons	Chloride of lime	75 percent used by coal colliery, 25 percent by inhabitants; see wells 777-780.
Orwigsburg	2,031	Orwigsburg Boro Water Co.	Stream and 1 drilled well (auxil- iary)	Catskill	35,000,000	120,000 gallons	None	See wells 882, 883. Small amount of water used by manufacturers.
Spring Glen	-----	J. Henry	1 spring	Mauch Chunk	4,000±	16 con- sumers	do	Supplies only part of town.
Tower City	2,482	Mr. Rheinhart	do	do	-----	18 con- sumers	do	Supplies only small part of town; rest supplied with sur- face water.

¹ Figures available only for incorporated places.

Drilled wells in Schuylkill County

No.	Location ¹	Owner or tenant	Topographic situation	Altitude above sea level ² (feet)	Depth (feet)	Diameter (inches)	Character of water bearing material	Geologic horizon	Depth of casing (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
768	North Union Twp. 1½ mile west of Zions Grove	Mr. Fuss	Hillside	1,080	62	6	Red shale	Mauch Chunk	15	22	10	D	
769	Union Twp. ¾ mile north-west of Ringtown	Mr. Ferguson	do	1,080	410	-----	Red sandstone	do	-----	130	30	do	Water level measured in 1928; first water 30 feet below surface.
770	Ringtown	Hotel	do	1,080	190	6	Red shale and sandstone	do	15	20	10	do	
771	do	Dr. Rhodes	do	1,080	60	6	-----	do	15	25	10	do	Moderate draw-down pumping 10 gallons a minute; dug well deepened by drilling.
772	¾ mile north-west of Krebs	-----	do	1,180	55	6	Gravel	Talus (?)	55	10	-----	do	Well does not reach bedrock.
773	¾ mile north of Krebs	J. Gilbert	Canyon	1,020	121	6	-----	Mauch Chunk	7	-----	-----	do	
774	East Union Twp. 1½ miles north-east of Krebs	John Kunchick	Hillside	920	80-90	6	-----	do	-----	-----	-----	do	Water level very low September 24, 1930.
775	Brandonville	Ben Pfifer	do	1,240	86	6	Red sandstone and shale	do	40	46	10	do	Depth to water level measured in 1914; water level is reported to have dropped 20 feet during a prolonged dry season.
776	1½ miles north-east of Brandonville	Shenandoah Boro. Water Co.	Canyon	1,020	995	10-3	do	do	-----	1½	200±	N	Flowed when drilled in 1904; used for municipal supply prior to 1920.
777	Oneida	Wyoming Valley Water Co.	Upland valley	1,600	700±	6	do	do	-----	15±	15±	P S	Flows in winter.

778	$\frac{1}{4}$ mile south of Oneida	do	Hillside	1,660	700±	6	do	do	-----	Flows 40-50	do	Flows 40 to 50 gallons a minute winter and summer.
779	$\frac{1}{4}$ mile south-east of Oneida	do	Upland valley	1,640	700±	6	do	do	-----	10-15	N	Pumps dry in 2 hours pumping 10 to 15 gallons a minute.
780	$\frac{1}{4}$ miles west of Oneida	do	do	1,620	700±	6	do	do	-----	15± 15	P S	Flows except during extremely dry seasons; stopped flowing about September 20, 1930.
781	Sheppton	Engigio Amer	High saddle	1,680	75±	6	Red shale	do	50	Flows -----	D	Flows 8± gallons a minute during 6 winter months; during the summer the depth to water level is 2 to 8 feet; bedrock overlain by 50 feet of sand.
782	$1\frac{1}{2}$ miles north-west of Girard Manor	George Lorah	Hillside	1,260	100	6	Red and green sandstone	do	6	47 7	do	Red shale 50 feet; red sandstone, green sandstone, and red sandstone, 50 feet.
783	Girard Manor	George Drumheller	Edge of valley	1,120	70	6	Red sandstone and shale	do	10	35 10	do	
	Kline Twp.											
784	0.4 mile west of McAdoo	Honeybrook Water Co.	Upland	1,880	1,014	6	-----	do	12±	Flows 150	P S	Two wells spaced 10 feet apart; flow during wet weather.
	Rush Twp.											
785	$\frac{1}{4}$ mile south-east of Hometown	J. M. Ryan	Canyon	1,100	100+	6	Red sandstone and shale	do	6±	Flows -----	do	
786	Hometown	Saylor's Bakery, Inc.	Hillside	1,160	205	8	do	do	65	12-15 60	I	Draw-down 75 to 80 feet pumping 60 gallons a minute; water was first encountered at a depth of 90 feet.
787	do	Harry Starch	do	1,220	98	6	do	do	32	----- 20	D	Small draw-down pumping 20 gallons a minute.
788	$\frac{1}{4}$ mile north-east of Barnesville	S. Teeter	Valley	1,060	58	5½	Hard blue sandstone	do	2±	38 4	do	A small amount of water was encountered at a depth of 45 feet.
789	Barnesville	J. Herring	Hillside	1,140	112	6	Red shale	do	16	30 10	do	Small draw-down pumping 10 gallons a minute.
790	do	Mr. Heff	Valley	1,020	50	6	Red sandstone	do	20	35 15	do	
791	do	Ray Clark	do	1,020	46	5½	Hard blue sandstone	do	13	3 -----	do	
792	Hawks Station	Philadelphia & Reading Railroad	Hillside	1,220	84	5½	Red shale	do	35	39 do	do	
793	$\frac{1}{4}$ mile south of Quakake Junction	T. Tropovitch	do	1,260	112	5½	do	do	20½	72 10—	do	Pumps dry in 10 minutes pumping 10 gallons a minute; soil 20½ feet, blue sandstone 60 feet, red shale 32 feet.

Drilled wells in Schuylkill County—Continued

No.	Location ¹	Owner or tenant	Topographic situation	Altitude above sea level ² (feet)	Depth (feet)	Diameter (inches)	Character of water-bearing material	Geologic horizon	Depth of casing (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
794	$\frac{3}{4}$ mile southwest of Quakake Junction Delano Twp.	H. Garber	Hillside	1,320	100	5 $\frac{1}{2}$	-----	Mauch Chunk	59	60	20+	D	Small draw-down pumping more than 20 gallons a minute; at a depth of 90 feet the drill bit dropped $\frac{1}{2}$ feet through a crevice containing considerable water.
795	$\frac{1}{4}$ mile north-east of Delano	Wyoming Valley Water Co.	do	1,700	500	8	-----	Pottsville	-----	10 $\frac{1}{2}$	75	N	Abandoned because of surface-water supply; depth to water level measured September 26, 1930.
796	do	do	do	1,700	500	10	-----	do	-----	10 $\frac{1}{2}$	125	P S	Two wells, same depth; one of the wells flows in wet seasons; depth to water level measured September 26, 1930.
797	Greer City	Henry Bachus	do	1,300	100	6	Red shale	Mauch Chunk	31	50	20	D	Small draw-down pumping 20 gallons a minute.
798	do Mahanoy Twp.	L. Bair	Small canyon	1,220	50	5 $\frac{1}{2}$	do	do	23	5	large	do	
799	$\frac{1}{2}$ mile north of Park Place	Wyoming Valley Water Co.	Canyon	1,740	500	10	-----	Pottsville	-----	13 $\frac{1}{2}$	5—	P S	Depth to water level measured September 26, 1930.
800	$\frac{3}{4}$ mile north-west of Park Place	do	Hillside	1,820	352	8	Sandstone and shale	do	-----	15 $\frac{1}{2}$	125	do	Well usually flows, but on September 26, 1930, the measured depth to water level was 15 $\frac{1}{2}$ feet; maximum flow is 50 to 75 gallons a minute; moderate draw-down pumping 125 gallons a minute; two drilled wells about 300 feet away are 500 feet deep and yield very little water.

801	1 mile south-east of Mahanoy City	German Cemetery	do	1,703	112?	-----	Gray and light sandstone	Post-Pottsville	11	40	20±	D	Small draw-down pumping 20 gallons a minute; gravel 11 feet, conglomerate 50 feet, gray sandstone 5 feet, conglomerate 20 feet, gray sandstone 5 feet, dark sandstone 5 feet, black rock 1 foot, gray sandstone (water-bearing) 10 feet, light sandstone (water-bearing) 5 feet.
	Ryan Twp.												
802	1 mile north-east of Mahanoy Tunnel Station	Mr. Blackwell	do	1,260	75	6	Red sandstone	Mauch Chunk	20	40	10-15	do	
803	1 mile north-west of East Mahanoy Jet. do	C. H. Kirscher	do	1,140	64	6	Red shale	do	38	22	22	do	Small draw-down pumping 22 gallons a minute.
834	do	Mr. Bruinbridge	do	1,140	90	6	-----	do	20	50	large	do	Several nearby wells, reported to be similar in depth and yield.
805	Lakeside Park	Lakeside Park	Valley	1,100	60, 62	6	-----	do	10	15	10	do	3 drilled wells; small draw-down pumping 10 gallons a minute.
806	1 mile south-west of East Mahanoy Jet. West Mahanoy Twp.	Harry Blue	Canyon	1,100	93	6	Hard rock	do	14	30	20	do	Small draw-down pumping 20 gallons a minute.
807	1 mile north of Shenandoah	Shenandoah Citizens Water & Gas Co. do	Hillside	1,600	560	8	-----	Pottsville	35	Flows	65	P S	Well 2; flows about 20 gallons a minute; yields about 65 gallons a minute by pumping.
808	do	do	Canyon	1,540	510	14-10	-----	do	30	32	large	do	Well 4; other wells nearby; well 1, 324 feet deep, well 3, 590 feet deep, well 5, 597 feet deep, all low Sept. 24, 1930.
809	Frackville	Mountain City Water Co., Nice St. plant	Hillside	1,400	402	8	Green sandstone	Mauch Chunk	4	S	120	do	Well 1; during summer draw-down is 116 feet pumping 120 gallons a minute for 1½ days; water level remains stationary; after 1½ days of pumping; during wet seasons draw-down is 80-85 feet pumping 130 gallons a minute; considerable water obtained from a 2-foot crevice in green sandstone at a depth of 380 feet; the rocks consist of gray and green sandstone and conglomerate. See analysis 809; temperature 52° F. September 1, 1931.

Drilled wells in Schuylkill County—Continued

No.	Location ¹	Owner or tenant	Topographic situation	Altitude above sea level ² (feet)	Depth (feet)	Diameter (inches)	Character of water-bearing material	Geologic horizon	Depth of casing (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
S10	Frackville	Mountain City Water Co., Nice St. plant	Hillside	1,400	520	10	Green and gray sandstone and conglomerate	Mauch Chunk	45	8	95	P S	Well 2; during summer draw-down is 116 feet pumping 95 gallons a minute for 1½ days, after which the water level remains stationary.
S11	do	do	do	1,460	535	8	do	do	-----	8	110	do	Well 3.
S12	do	do	do	1,460	651	8	do	do	40±	8	45	do	Well 4; during summer draw-down is 116 feet pumping 45 gallons a minute for 1½ days, after which the water level remains stationary.
S13	do	do	do	1,400	525	8	do	do	-----	8	150	do	Well 5; during summer draw-down is 116 feet pumping 150 gallons a minute; wells 1 to 5 are spaced 30 to 120 feet apart.
S14	do	Mountain City Water Co., Center St. plant	do	1,420	452	12	Red shale and sandstone	do	50	10	350	do	Well 1; draw-down 217 feet pumping 350 gallons a minute for 24 hours, after which the water level remains stationary.
S15	do	do	do	1,420	320	-----	do	do	-----	10	200	do	Well 2; draw-down 217 feet pumping 200 gallons a minute for 24 hours, after which the water level remains stationary.
Butler Twp.													
S16	Girardville	Creamery	Valley	960	150	8	"Slate"	Post-Pottsville	40	18±	80	I	Draw-down about 12 feet pumping 80 gallons a minute for 10 hours.
S17	do	Frackville Gas Co.	do	960	120	8	do	do	35	18±	75	do	
S18	1½ miles east of Fountain Springs	Immaculate Heart Academy	Hilltop	1,080	620	8	Red sandstone	Mauch Chunk	50	105	40-50	D	Approximate log, red shale 400 feet, hard red sandstone 220 feet.
S19	Fountain Springs	Fountain Springs Beverage Co.	Canyon	960	120	6	-----	do	-----	80-85	10±	I	

820	do	Bud Selzer	Hillside	920	70			do	15	Flows		D	Well flows about 9 months a year; 68 feet to principal water-bearing bed.
821	$\frac{1}{2}$ mile west of Fountain Springs	Asbland State Hospital	do	980	418	10	Crevice in red sandstone	do	9	155	65	H	Auxiliary to surface-water supply; water encountered in 18-inch crevice at a depth of 380 feet; some water at 30 and 111 feet; draw-down about 35 feet pumping 70 gallons a minute for 7 minutes.
822	0.3 mile west of Fountain Springs	M. L. Miller	do	960	455	6	Red sandstone	do	30	70	30	D	Draw-down 120 feet pumping 120 gallons a minute for 20 minutes; water obtained between 435 and 455 feet; 8 gallons a minute at depth of 70 feet.
823	$\frac{3}{4}$ mile north-west of Gordon	Asbland Pure Ice Co.	do	920	198	6		do		16±	65±	Ice	
824	$\frac{3}{4}$ mile north-west of Gordon	Joe Hatchel	Hillside	900	100			do	23	30-63		D	Depth to water normally 30 feet; dropped 33 feet during summer of 1930.
825	Lavelle	Romeo Hormig	do	980	72	5½	Red sandstone and shale	do	35	61	5	do	A large mass of pyrite struck at a depth of 53 feet.
	Barry Twp.												
826	$\frac{1}{2}$ miles west of Barry	William Wolfgang	do	1,020	71	6		do	36			do	
827	Taylorville	Harry Dangier	Valley	320	50	5½	Blue "rock"	do	12			do	Flows in wet weather; in dry weather the water stands 15 to 20 feet below the surface.
828	$\frac{1}{2}$ miles south-west of Gordon	George Crust	Hillside	920	75	5½	Hard red sandstone	do	19	17	Small	do	Some water at a depth of 35 feet.
829	2 miles south-east of Taylorville	Harvey Berry	Canyon	1,220	68		Red sandstone	do	16	53		do	
830	Mabel	Daniel Lubold	Hillside	920	59½	6		do	20			do	
831	do	Francis Yarno	do	920	85	6	Hard red sandstone	do	21		Very small	do	
832	Weishample	Church of God	Valley	880	75	6		do	38	40		do	Water encountered at a depth of 40 feet.
	Eldred Twp.												
833	2 miles west of Lavelle	Mr. Beaver	Hillside	940	102	5½	Soft gray sandstone	do	60	62	8	do	Pumps dry in $1\frac{1}{2}$ hours pumping 10 gallons a minute; 6 months after well was drilled 40 feet of sand had accumulated in the bottom.

Drilled wells in Schuylkill County—Continued

No.	Location ¹	Owner or tenant	Topographic situation	Altitude above sea level ² (feet)	Depth (feet)	Diameter (inches)	Character of water-bearing material	Geologic horizon	Depth of casing (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
834	Helfenstein	Mort Weikel	Hillside	890	53	5 $\frac{1}{2}$	Red shale	Mauch Chunk	25	27	-----	D	
835	Pitman Upper Mahan- tango Twp.	Feix Herb	do	940	100	6	Red sand- stone	Catskill	28	30+	5	do	
836	Klingerstown Hubley Twp.	Samuel Reed	Valley	520	50	6	do	do	22	5-6	20±	do	
837	Fearnot	Ralph Shade	do	600	47	6	do	Mauch Chunk	-----	10±	-----	do	
838	Spring Glen	Junior Meeh	do	620	86	6	Red shale	do	18-20	26-38	large	do	Some water encountered at a depth of 47 feet.
839	Sacramento Hegins Twp.	Francis Matten	Hillside	700	90	5 $\frac{1}{2}$	do	do	19	17	8	do	
840	1 $\frac{1}{2}$ miles west of Valley View	Harry Schrader	Saddle	760	107	6	Red sand- stone and shale	do	25	32	-----	do	
841	1 mile south- west of Valley View	Mr. Schwahn	Valley	700	90	6	Red shale	do	18-20	-----	16	do	
842	$\frac{3}{4}$ mile north of Valley View	Joe Bixler	Hillside	780	108	5 $\frac{1}{2}$	Red sand- stone and shale	do	20	28	-----	do	Dug 23 feet, drilled to 65 feet.
843	1 mile south- west of Hegins	Frank Miller	do	740	62	6	Red sand- stone	do	48	40-	-----	do	
844	Hegins Porter Twp.	Harvey Reed	Saddle	880	65	6	-----	do	23+	23	5	do	
845	$\frac{3}{4}$ mile north- west of Rein- erton	E. F. Warkman	Hillside	860	60	6	-----	do	-----	45	-----	do	

846	$\frac{1}{2}$ mile north of Muir	Mr. Wheatley	do	980	116	-----	Red sandstone and shale	do	41	-----	-----	do	
847	Muir	R. R. Evans	Valley	760	52	6	Red sandstone	do	15-20	26	-----	do	
848	do	Garvin Bixler	do	760	101	6	do	do	20	30-50	8	do	Depth to water 50 feet in summer, 30 feet in winter. Flows 1-inch pipe full.
849	Joliett	Philadelphia & Reading Coal & Iron Co.	Hillside	1,460	400	-----	-----	Pottsville	-----	Flows	-----	do	
850	do	do	do	1,460	1,000	12	-----	do	-----	-----	-----	do	Also has a 300-foot well.
	Reilly Twp.												
851	Newtown	Mr. Hildebrand	do	940	71	6	Yellow and gray sandstone and shale	Post-Pottsville	16	20	-----	do	
852	Branchdale	Mr. Zimmerman	Canyon	800	106	6	Sandstone	do	18	40	3-4	do	
	Branch Twp.												
853	$\frac{3}{4}$ mile southwest of Minersville	Mr. Snyder	Ridge	920	87	6	Shale	do	-----	47	1	do	A bed of coal 2 to 3 feet thick was struck at depth of 80 feet.
	Norwegian Twp.												
854	Pottsville	W. E. Treon	Hillside	720	96 $\frac{1}{2}$	5 $\frac{1}{2}$	Sandstone	do	35	15 \pm	12	C	Struck coal at the bottom; see analysis 854; temperature 53° F. August 31, 1931.
855	do	Yuengling's Brewery	do	720	476	-----	do	do	-----	140	30	do	Draw-down 134 feet pumping 55 gallons a minute for 4 hours. Has another drilled well yielding 55 gallons a minute continuously.
	Blythe Twp.												
856	1 $\frac{1}{2}$ miles southeast of Middleport	John Silesky	High saddle	1,100	115	5 $\frac{1}{2}$	Red sandstone and shale	Mauch Chunk	8 $\frac{1}{2}$	25	6	do	
	Schuylkill Twp.												
857	$\frac{1}{2}$ mile northeast of Brockton	Mary D. Service Station	Valley	820	42	5 $\frac{1}{2}$	Coal	Post-Pottsville	22	-----	Small	N	Coal struck at 30 feet; well ends in coal; water black and unfit for drinking.

Drilled wells in Schuylkill County—Continued

254

No.	Location ¹	Owner or tenant	Topographic situation	Altitude above sea level ² (feet)	Depth (feet)	Diameter (inches)	Character of water-bearing material	Geologic horizon	Depth of casing (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
858	Tuscarora Walker Twp.	H. Steinmetz	Hillside	920	52	-----	Sandstone	Post-Pottsville	32+	10	10+	D	Small draw-down pumping more than 10 gallons a minute; soil 10 feet, gray shale 10 feet soft sandstone 10 feet, coal 2 feet, sandstone (water-bearing) 20 feet.
859	1½ miles south-west of Tamaqua	W. Emerick	do	1,060	103	6	Red shale	Mauch Chunk	9	-----	Very small	do	Well unfinished.
860	¾ mile south of Tamaqua Rahn Twp.	C. F. Dunn	do	1,300	94	6	Yellow sandstone	do	9	47±	3	do	Pumps dry pumping more than 3 gallons a minute; soil 9 feet, red sandstone 10 feet, yellow sandstone 75 feet.
861	Tamaqua	Billman & Stegmaier	Valley	960	116	5½	Hard conglomerate	Post-Pottsville	30	15	30	I	Pumps dry in ½ day pumping 30 gallons a minute.
862	1 mile south of Tamaqua West Penn Twp.	Mr. Shelheimer	do	860	100	8	Red shale	Mauch Chunk	30	8	25	do	
863	1½ mile east of So. Tamaqua	George Ames	Hillside	780	71	6	Dark shale	Portage	20±	18	3	D	Dug 46 feet, drilled to 91 feet.
864	½ mile east of West Penn	Mr. Long	Valley	720	75	-----	Yellow sandstone	do	1½	11	20	do	
865	½ mile south of West Penn East Brunswick Township	Mr. Schaeffer	Hillside	900	91	6	-----	Catskill	-----	48±	-----	do	

866	3 miles north-east of New Ringold	Leon Kleckner	do	860	91	6	Gray "slate"	Portage	-----	23	3	do	Dug and drilled.
867	New Ringold	Mr. Reed	Valley	560	132	6	Black "slate"	do	-----	25±	16	do	Small draw-down pumping 16 gallons a minute.
868	do	George Ternblin	do	580	80½	5½	Brown sand-stone	Hamilton	12	-----	6	do	
869	½ mile south of New Ringold	Mr. Fantz	Valley	540	125	-----	Red shale	Cayuga	20	30	20	do	
870	McKeansburg	Claude Walters	Upland	700	85	6	do	do	19½	30±	16	do	Small draw-down pumping 16 gallons a minute; depth to water level 20 feet when drilled, later dropped to 30± feet.
871	do	J. D. Riegel	do	700	86	6	-----	do	-----	33	-----	do	Dug 23 feet, drilled to 86 feet.
West Brunswick Township													
872	½ mile south of Dreher'sville	Jeremiah Hafer	Hillside	560	123½	6	Red shale	do	10	30	12	do	
873	¾ mile north-east of Port Clinton	D. Klodren	do	720	315	5½	do	do	16-18	80±	15	do	Moderate draw-down pumping 15 gallons a minute.
874	Port Clinton	J. E. Moyer	Valley	440	80	6	Red sand-stone and shale	do	27	25±	-----	do	Water reported to be hard.
875	do	Robinhole & Co.	do	420	119	5½	do	do	15	11	25	I	Drawdown 19 feet pumping 25 gallons a minute for ½ hour; see analysis 875; temperature 61° F. September 2, 1931.
876	do	Wm. McAtu	do	440	110	5½	Red sand stone	do	-----	30	3	D	
877	¾ mile north-east of Auburn	Delaware Tube Mill	do	460	250	6	Dark sand-stone and shale	Portage (?)	20±	15-20	25	I	Abandoned; used only during emergencies.
878	2 miles north-east of Auburn	Chas. Faust	do	500	123	5½	Black "slate"	Portage	14	15	21	D	Draw-down 25 feet pumping 21 gallons a minute for 5 to 10 minutes, after which the water level remains stationary.
879	2¼ miles north-east of Auburn	Mr. Gleich	do	500	135	6	Black shale	do	30	25	20	do	Odor of hydrogen sulphide.
880	Southeast of Orwigsburg	Church	do	520	99	6	Red "rock"	Cayuga	20	20±	3	do	
881	1 mile south-east of Orwigsburg	J. Olivet	Hilltop	600	260	6	Red and yellow shale	do	-----	80	large	D	

Drilled wells in Schuylkill County—Continued

226

No.	Location ¹	Owner or tenant	Topographic situation	Altitude above sea level ² (feet)	Depth (feet)	Diameter (inches)	Character of water-bearing material	Geologic horizon	Depth of casing (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
882	1 mile north-west of Orwigsburg	Orwigsburg Water Co.	Canyon	640	300	6	Blue-black "slate"	Portage	12	3	12—	N	Large draw-down pumping 12 gallons a minute for $\frac{1}{2}$ hour; abandoned just after being drilled.
883	2 miles north-west of Orwigsburg North Manheim Township	do	do	900	200	6	Sandstone	Catskill	30	30±	90	P S	Second well drilled; draw-down 10 feet pumping 90 gallons a minute for 24 hours.
884	1½ miles south-west of Orwigsburg	Mr. Brosbes	Valley	560	60	6	Black shale	Marcellus	-----	15±	10	D	
885	do	Carl Bohrmann	do	580	50	5½	Hard brown sandstone	Oriskany(?)	16	20	7½	do	
886	1½ miles north-east of Schuylkill Haven	Sammy's Auto Graveyard	Saddle	620	112	5½	Gray "slate"	Marcellus	20	15±	25	do	Small draw-down pumping 25 gallons a minute.
887	do	Mohan Bros.	do	620	72	5½	-----	do (?)	-----	20	15	do	
888	do	do	do	620	153	5½	-----	do (?)	-----	40	6	do	
889	do	R. B. Aulenback	do	620	112	5½	Gray "slate"	do (?)	20	15±	15	do	Draw-down 11 feet pumping 15 gallons a minute.
890	¾ mile north of Schuylkill Haven	Schuylkill County Alms House	Hillside	580	188	8	Red shale	Cayuga (?)	Shallow	80±	-----	do	Flows in wet weather; depth to water 80 feet September 29, 1930.
891	do	do	do	580	300	8	do	do(?)	do	120±	100	do	
892	½ mile north of Cressona	Schuylkill Haven Water Co.	Valley	560	836±	-----	Red shale and blue sandstone	Portage	20	80	50	P S	
893	do	do	do	560	235	-----	do	do	20	80	80	do	3 wells, 200 feet apart.
894	Adamsdale	Mr. Adams	do	500	47	6	Dark shale	Hamilton	18	20±	3-4	D	
895	Landingville	Emma Dibot	do	500	75	5½	Black "slate"	Portage	20	-----	5½	do	Black "slate" overlain by sandstone.

	South Manheim Township													
896	$\frac{1}{2}$ mile south of Schuylkill Haven	George Buehler	Ridge	800	74	5 $\frac{1}{2}$	Brown sandstone	do	14	14	-----	do		
897	do	E. Poxoe	do	700	157	-----	Gray, green and brown sandstone	do	-----	40-50	5-6	do		
898	Jefferson	F. Sower	Valley	540	131	5 $\frac{1}{2}$	Hard blue slate (?)	Marcellus(?)	10	15-18	$\frac{1}{4}$	do	Pumps dry pumping $\frac{3}{4}$ gallon a minute.	
899	$\frac{3}{4}$ mile west of Jefferson	John Helm	do	600	150	5 $\frac{1}{2}$	do	do	-----	40	-----	do	Blue slate(?) overlain by yellow shale; adequate supply; see analysis 899; temperature 54° F. September 2, 1931.	
	Wayne Township													
900	$\frac{2}{3}$ miles west of Cressona	Schuylkill Haven Water Co.	High saddle	740	640	-----	Red shale and sandstone	Catskill	20	80	60-80	P S	First water encountered at a depth of 90 feet.	
901	Friedensburg	Mr. Reed	Valley	640	55	6	Gray "slate"	Portage	20	25 \pm	3	D		
902	1 mile south-west of Friedensburg	H. A. Herring	Hillside	800	157	5 $\frac{1}{2}$	Red shale	do	13 $\frac{1}{2}$	30	5 $\frac{1}{2}$	do		
903	Summit	F. Strauss	Valley	700	112	5 $\frac{1}{2}$	Shale	Hamilton	-----	15	18 \pm	do		
904	$\frac{1}{4}$ miles west of Summit	Elias Worth	do	700	80	5 $\frac{1}{2}$	Black sand stone	do	17	-----	-----	do	Black sandstone overlain by black shale.	
905	$\frac{2}{3}$ miles west of Summit	Ed. Banning	do	700	81	5 $\frac{1}{2}$	Gray sandstone	do	45	30	15 \pm	do	Gray sandstone overlain by shale.	
906	$\frac{2}{3}$ miles east of Rock	F. Kirschener	Hillside	680	73	5 $\frac{1}{2}$	Dark blue "rock"	do	19 $\frac{1}{2}$	20	20	do	Small draw-down pumping 20 gallons a minute.	
	Washington Township													
907	2 miles north-east of Washington	John A. Freeman	do	680	93	5 $\frac{1}{2}$	Red shale	Portage	10 $\frac{1}{2}$	-----	12	do		
	Pine Grove Township													
908	North Pine Grove	George Lehman	Valley	580	45	5 $\frac{1}{2}$	Brown sandstone	Catskill	21	20	6	N	Abandoned because of iron in water.	
909	$\frac{1}{4}$ miles north of Pine Grove	Elias Kintzel	do	580	65.8	6	Sandstone	Portage	-----	8.3	-----	D	Water level measured September 2, 1931; reported to flow during rainy seasons; see analysis 909; temperature 54° F. September 2, 1931.	

Drilled Wells in Schuylkill County—Continued

No.	Location ¹	Owner or tenant	Topographic situation	Altitude above sea level ² (feet)	Depth (feet)	Diameter (inches)	Character of water-bearing material	Geologic horizon	Depth of casing (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
910	1½ miles north of Pine Grove	Ed. Britz	Hillside	560	82	5½	Yellow shale	do	16	18±	15	D	
911	1¼ miles north of Pine Grove	Pennsylvania Power & Light Co.	do	560	260	8	Sandstone	Hamilton	-----	30±	26+	do	Supplies 20 homes and drinking water at plant; see analysis 911; temperature 56° F., September 2, 1931.
912	1½ miles east of Pine Grove	M. Clements	Hilltop	800	180	6	Gray sandstone	Portage	-----	50	2	do	Sandstone overlain by shale.
913	½ mile southeast of Pine Grove	Nick C. Donofrio	Hillside	560	30.8	24	Black shale	do	30.8	23.6	-----	N	Dug well; depth to water level measured October 21, 1931; see pl. 4 and fig. 3.
914	1 mile south of Pine Grove	Elias Hope	do	580	82	5½	do	Marcellus	12½	35	10	do	
915	¼ mile west of Beuchler	Paul Fiedler	do	640	75½	5½	Yellow shale	Portage	12½	30	15	do	
916	¾ mile west of Outwood	George Boyer	Canyon	600	53	6	Hard blue sandstone	Catskill	15	50±	-----	do	Depth to water level 5± feet in wet seasons, 50± feet during summer of 1930.
917	½ mile south of Suedberg	George Doubert	Valley	500	68½	5½	Sandstone	Hamilton	11	20	25	do	Small draw-down pumping 25 gallons a minute; sandstone overlain by yellow shale.

¹ If no distance is given well is located in town.² Generally estimated from nearest contour line or bench mark on topographic map.³ C—Cooling; D—Domestic; I—Industrial; N—None; PS—Public supply.

SUSQUEHANNA COUNTY

GENERAL FEATURES

[Area 824 square miles, population 33,806]

Susquehanna County is at the north end of the area described in this report and lies between Bradford and Wayne Counties on the New York State line. It is the second largest county in the area. The population is largely rural, as most of the villages have less than 1,000 inhabitants and Forest City, with a population in 1930 of 5,209, is the only borough in the county with 5,000 or more. In 1930 there were 3,170 farms in Susquehanna County, which is more than in any other county covered by this report. Most of them are small dairy farms scattered along the valleys and gently rounded hills, for there are very few large areas of flat land. There were only 41 manufacturing establishments in the county in 1929 whose annual products were valued at \$5,000 or more each.

SURFACE FEATURES

The highest point in the county is in the southwest corner of Herrick Township, where North Knob of the Elk Hills reaches an altitude of 2,684 feet above sea level. Most of the county is high and rolling. The greater part of the county lies above 1,500 feet in altitude, and near the Wayne County line altitudes above 2,000 feet are not uncommon. The lowest part of the county is in the vicinity of Great Bend, where Susquehanna River enters New York State. The Great Bend station is 884 feet above sea level. The maximum relief is therefore about 1,800 feet. The greatest local relief occurs along streams, such as Martins Creek, which have cut through the hard sandstones of the New Milford formation. In striking contrast to this is the broad valley of Susquehanna River, flowing through the softer Chemung rocks. There are a few patches of flat land on terraces along the Susquehanna.

Susquehanna County is drained entirely by the North Branch of Susquehanna River and by its tributaries. Susquehanna River enters from New York near the northeast corner of the county and reenters New York just north of the town of Great Bend, Pa. The river does not again reenter Susquehanna County but comes within 4 miles of the southwest corner. As the county lies entirely north of the glacial border, there are numerous undrained areas occupied by lakes and swamps.

GEOLOGY AND GROUND WATER

GENERAL SECTION

Susquehanna County lies well to the north of the Wisconsin terminal moraine and, with the exception of the summit of Elk Hills, was entirely covered by ice. Deposits of glacial drift of variable thickness cover the whole county except where they have been removed by erosion.

The rock formations exposed in Susquehanna County range from the Post-Pottsville down to the Chemung. The youngest formations—the Post-Pottsville and Pottsville formations, Mauch Chunk shale, and Pocono sandstone—are exposed only in the southeast corner of the county. The oldest rocks are exposed along the western and northern boundaries.

Generalized section for Susquehanna County

Geologic formation	Maximum thickness exposed (feet)	Character of rocks	Ground-water conditions
Glacial drift (Wisconsin)	200±	Till (boulders, clay, sand, and gravel) and outwash (clay, sand, and gravel).	Till yields small supplies of potable water to numerous dug wells. Outwash yields large supplies of very soft potable water, but not extensively utilized as source of water.
Post-Pottsville and Pottsville formations	200+	Conglomerate, sandstone, slate, and coal.	
Mauch Chunk shale	0—170	Hard gray sandstone, pebbly white sandstone, dark and reddish shale.	Unimportant as source of ground water; small area of outcrops; no wells reported.
Pocono sandstone	665±	Pebbly conglomerate, sandstone, and buff sandy shale.	
Catskill group	1,800±	Chiefly red shale and gray cross-bedded sandstone, with some conglomerate, red, green, and white sandstone, gray and olive-green shale, a few thin streaks of coal; contains fish remains.	Sandstone beds yield moderate supplies of good water. Most important water-bearer in county.
Chemung formation	380±	Olive-green, fossiliferous shale, red, green, and purple shale, and red, olive-green and green sandstone.	Yields small to moderate supplies of fair water. Deeper wells may encounter salt water.

STRUCTURE

The geologic structure of Susquehanna County is relatively simple compared to that of most of the other counties covered by this report. The major structural feature of the region is the Lackawanna syncline or coal basin, which terminates in the southeast corner of the county but whose axis turns and runs due north along the Wayne County line. To the northwest of this synclinal axis the strata dip rather steeply to the southeast, but they flatten out to a nearly horizontal plane within 4 or 5 miles. Then comes a reversal of dip toward Tunkhannock Creek, to the northwest on the axis of an anticline that continues southwestward as far as Union and Clinton Counties. This anticline dies out to the northeast in about the center of Herrick Township. The rocks in the remaining part of the county lie almost horizontal but are folded locally into minor anticlines. Several folds entering Susquehanna County from Bradford County flatten out and disappear to the east. The Wilmot anticline enters at the southwest corner of the county and extends across Auburn Township. Its southward dips are rarely more than 50 to 75 feet to the mile, so that the strata in the southern part of the county are nearly horizontal. The Towanda or Rush anticline of Bradford County crosses Rush Township and fades, and the Rome anticline of Bradford County extends through Friendsville to Hallstead.

WATER-BEARING FORMATIONS

[See pp. 41-54 for further description]

Glacial drift.—Susquehanna County was almost entirely covered by ice during the last glacial stage. The general direction of ice movement was about S.28°W., but bare rock surfaces were observed bearing striae

trending S.28°W. to S.60°W. White⁹⁸ placed the upper limit of glaciation in this region at 2,200 feet, so that the Elk Hills stood out as islands. Over the remainder of the county the highlands were planed off, many valleys were gouged out, and a great quantity of glacial drift was deposited over the rock surface. Several wells are reported with casing lengths of more than 100 feet. The glacial drift consists of both till and stratified outwash.

Glacial till yields small quantities of water to numerous dug wells, and probably supplies more wells than any other formation in the county. It is also the source of many small springs, some of which are utilized (p. 264). The stratified drift containing lenses of water-bearing sand or gravel yields larger supplies than the till.

The larger valleys as well as some of the smaller ones are filled in most places with glacial outwash deposits. Susquehanna River flows over a buried valley through most of its course within the county, and there is an abandoned channel about 1½ miles east of Great Bend and another about 1 mile east of Hickory Grove. Very few well records are available along the valley, but it was reported that the valley fill in the vicinity of Binghamton, N. Y., ranges in depth from 190 to 300 feet. Broad terraces line Susquehanna River in most places, and many conical mounds of stratified drift are found on the terraces. (See pl. 6-B.)

In a small area of the county along the Susquehanna River Valley and to a lesser extent along the smaller streams such as Tunkhannock and Martins Creeks the outwash sand and gravel of the glacial drift are potential sources of ground water. Their importance has not yet been fully realized, however, as there are very few drilled wells that end in sand or gravel, and most of the wells are cased through the glacial drift into the underlying bedrock. The drilled well of the Oakland Water Co. (well 8) is the only drilled well recorded along the Susquehanna River Valley that obtains water from the sand and gravel in the glacial drift. This well is only 22 feet deep and 4 inches in diameter. It ends with an open finish in gravel and yields 164 gallons a minute. This is by far the strongest well recorded in the county, but it is probable that with more modern methods of finishing such wells by means of screens or strainers much larger yields could be obtained. This method of developing wells is also applicable in some places where layers of fine sand would render an ordinary open-finished well unsatisfactory if not a complete failure. The use of well screens and strainers is further discussed on pp. 33-35.

Post-Pottsville, Pottsville, Mauch Chunk and Pocono formations.—The post-Pottsville, Pottsville, Mauch Chunk and Pocono formations crop out only in a small triangular area at the southeast corner of the county, and are unimportant as sources of ground water owing to their small areal extent, to the coal mining in the post-Pottsville and to the rugged, forested outcrops of the other three formations.

Catskill continental group.—With the exception of small areas in the southeastern, northern and western parts, all of Susquehanna County is underlain by rocks of the Catskill continental group. The Mount Pleasant, Elk Mountain, Cherry Ridge, Honesdale and Damascus formations crop out in the southeastern part of the county. The Honesdale and

⁹⁸ White, J. C., *Geology of Susquehanna County and Wayne County: Pennsylvania Geol. Survey, 2d ser., Rep. G5, p. 25, 1881.*

Damascus also crop out at Montrose, and by far the larger part of the county is underlain by the New Milford formation.

The Catskill group contains numerous beds of water-bearing sandstone and sandy shale, which can be reached by drilled wells of moderate depth. The water generally occurs in fractures and bedding planes. (See pl. 5-A.) Nearly all the drilled wells in Susquehanna County obtain water from sandstones and to a lesser extent from shales of the Catskill, and most of these wells are in the New Milford formation. Moderate supplies are usually obtained from the Catskill at depths ranging from 50 to 100 feet, but many of the industrial wells obtain somewhat larger supplies at depths of from 200 to 500 feet. The water obtained from the Catskill is generally entirely satisfactory for most purposes.

Chemung formation.—In Susquehanna County only about the upper 380 feet of the marine Chemung formation is exposed, and the outcrops are limited to small areas along the northern and western parts of the county. A few drilled wells obtain adequate supplies of water from the sandstones and shales of this formation. The water is generally of less desirable quality than that from the overlying formation, and deep wells are likely to encounter salt water. (See well 4.)

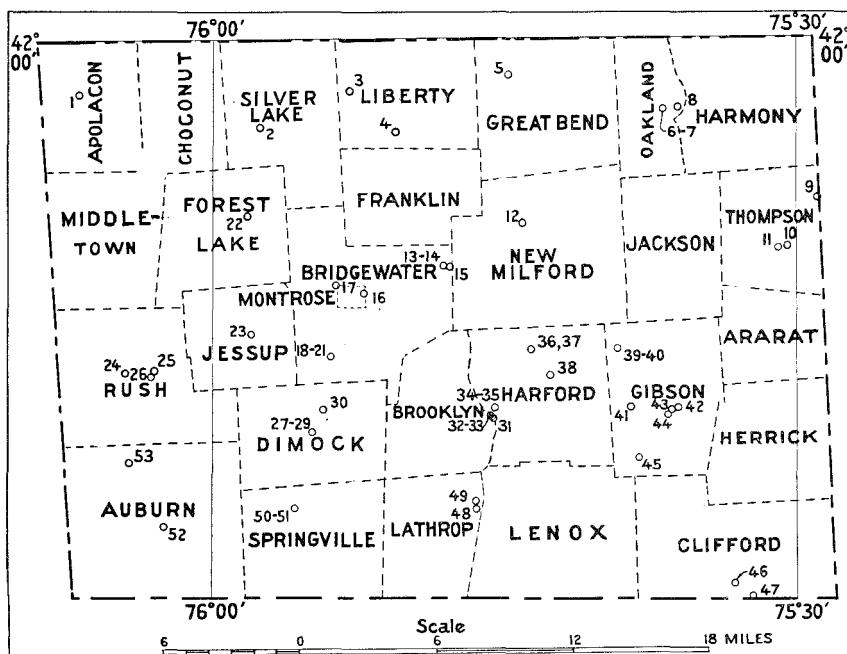


Figure 16. Map of Susquehanna County showing location of water wells.

ARTESIAN CONDITIONS

The structure of the rocks in Susquehanna County is relatively simple, but artesian pressure sufficient to cause the water to rise some distance above the level where water was first encountered is found in many of the bedrock wells. The well of the Gibson Dairy Association (well 40)

is the only one recorded in the county in which the artesian pressure is sufficient to cause the well to flow. It is possible that flowing wells might be obtained along the southeastern slope of Lackawanna Mountain above Forest City, as the structure there is very similar to that farther south, in Lackawanna and Luzerne Counties, where numerous flowing wells have been drilled.

QUALITY OF WATER

Fourteen samples of water were collected in Susquehanna County, the analyses of which are tabulated on page 272. The water collected from 11 wells and springs in the hard-rock formations contained an average of 130 parts per million of total dissolved solids and had an average hardness of 96 parts per million. The three samples of water collected from wells and springs in the glacial drift contained an average of only 62 parts per million of total dissolved solids and had an average hardness of 38 parts per million. Only one sample contained an excess of iron. (See analysis 22.)

A well in Lawsville Center (well 4) obtains very salty water from the Chemung formation. The water is used for washing milk cans but it is too salty for drinking.

A spring on the bank of a small stream about 1 mile west of Franklin Forks yields about 10 gallons a minute from thin-bedded sandstone in the Chemung formation. The water is very salty and deposits iron at the overflow. Bubbles of inflammable gas rise to the surface and can be ignited with a match, and a gas well about 200 feet from the spring supplies a farm house with gas for cooking. It seems probable that the gas is methane (CH_4), as this gas is known to come from gas wells in the Chemung formation in several of the counties in the north-central part of Pennsylvania. Near the center of Middleton Township a test hole for oil was drilled to a depth of 680 feet⁹⁹. No oil was obtained, but gas and salt water were found in the Chemung formation at a depth of 300 feet. A nearby well 300 feet deep supplied brine for the manufacture of salt. The old county reports mention salt springs in Apolacon, Auburn and Franklin Townships that were used by early settlers as sources of salt.

Except for these occurrences of salt water in beds of the Chemung formation, the ground waters of Susquehanna County are entirely satisfactory for most purposes.

PUBLIC SUPPLIES

The subjoined table shows that there are only six public supplies in Susquehanna County using ground water. Forest City, Montrose, Susquehanna Depot, and Great Bend are all supplied by surface water, and in the remaining villages the inhabitants are supplied by individual springs and wells. Thus although more places use ground water than surface water, the largest boroughs, Forest City and Montrose, are supplied by surface water, and therefore the consumption of surface water far exceeds that of ground water. All the boroughs using ground water obtain their supplies from one or more springs, and four of the six have one or more auxiliary wells for use during exceptionally dry seasons. Chlorination is required only at two of the ground-water public supplies.

⁹⁹ White, I. C., op. cit., p. 20.

Some of the public supplies from springs are unreliable during prolonged dry seasons. New Milford uses some surface water when the springs get low, but most of the villages resort to auxiliary wells. It is probable that future demands will be best met by drilling additional wells.

INDUSTRIAL SUPPLIES

The largest industrial users of ground water in Susquehanna County are the creameries that are scattered all over the county. Most of the creameries obtain water from drilled wells, but a few of them are supplied by springs. The water is used for washing milk cans and bottles, for boiler use, and at some plants for cooling.

DOMESTIC SUPPLIES

Most of the domestic water supplies in Susquehanna County utilize dug wells, which obtain small quantities of water from the glacial drift. Some of these wells are reported to go dry during the summer. Although there are at present relatively few drilled wells in the county, they are becoming increasingly popular because they are less subject to contamination and are more reliable during dry seasons. Numerous small springs are utilized for domestic supply.

Well 51, on a hillside in Springville, is dug about 4 feet deep into glacial drift and provided with an overflow pipe about 3 feet below the surface of the ground. The overflow on July 14, 1930, just after a heavy rain, measured 9.1 gallons a minute. On July 22d, after a brief dry spell, the overflow was remeasured and found to be only 3.17 gallons a minute. This shows that in a region of shallow water-table, the water level may rise appreciably very shortly after a heavy rain.

SPRINGS

There are many small springs in Susquehanna County, some of which are provided with overflow pipes so that their yield could be measured by means of a 1-gallon measure and a stop watch, but most of them have no such improvements, and the yield could only be estimated. Although most springs are reported to have constant yields the year around, actual flow measurements show that they fluctuate considerably and usually decrease during the dry summer.

The Half Way Spring House, about half a mile north of Hopbottom, has three springs that are used to supply passing motorists with drinking water. The water in all three of these springs appears to come from bedding planes in Catskill sandstone and on July 10, 1930, they flowed 3.8, 4.4, and 2.4 gallons a minute respectively. The spring yielding 2.4 gallons a minute was remeasured on July 21, 1930, and the flow had decreased to 1.3 gallons a minute. (See analysis 1217.)

The Spencer Spring, owned by the Thompson Borough Water Co., probably obtains its water from the glacial drift. On July 9, 1930, the spring flowed 9.3 gallons a minute and when measured again on July 21, 1930, the flow had decreased to 7.6 gallons a minute. (See analysis 1215.)

Public water supplies in Susquehanna County derived from ground water

Borough and Owner	Population 1930 ¹	Source	Geologic source	Storage (gallons)	Average daily con- sumption	Treatment	Remarks
Brooklyn Mr. Rayknop	-----	6 or 8 springs and 1 dug well (auxiliary)	Glacial drift	22,000±	-----	None	Dug well 18 feet deep, 6 feet to water.
Hopbottom Hopbottom Water Co.	354	7 springs and 1 drilled well (auxiliary)	Springs, glacial drift; well, Catskill	200,000±	63	Chlorine gas (well)	Supply decreasing from year to year. See well 49.
Kingsley A. J. Masters	-----	1 spring	Catskill	900	24 consumers	None	See analysis 1216. Decreases in summer but gives adequate supply.
New Milford New Milford Water Co.	782	11 springs	-----	248,000±	36,000± gallons	Chlorine gas	Used by 50 percent of inhabitants. In dry seasons springs get low. Some surface water used.
Oakland Oakland Water Co.	1,040	15 springs and 3 drilled wells (auxiliary)	Springs and 1 well, glacial drift; 2 wells Chemung	33,850	242 consumers	None	About 2 percent used for manufac- turing. See wells 6 to 8; anal- ysis 8.
Thompson Thompson Borough Water Co.	321	3 springs (1 aux- iliary) and 1 drilled well (auxiliary)	Springs, glacial drift; well Catskill	53,000	-----	do	Serves 90 percent of inhabitants. See analysis 1215, also well 11.

¹ Figures available only for incorporated places.

Drilled wells in Susquehanna County

No.	Location ¹	Owner or tenant	Topographic situation	Altitude above sea level (feet) ²	Depth (feet)	Diameter (inches)	Character of water-bearing material	Geologic horizon	Depth of casing (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
1	Apolacon Twp. 1 mile south of Little Meadows		Hillside		19.8		Drift	Glacial drift		19.8±		N	Dug well nearby is dry during summer.
2	Silver Lake Twp. North shore of Silver Lake		Lakeside		25±		do	do		10±		S	Water level very low in summer.
3	Liberty Twp. Tripp Lake		do		217	6	Gray sand stone and shale	Chemung	10±	90		D	
4	Lawsville Center	Lawsville Co-operative Creamery	Valley		280±	3	Sandstone and shale	do				I	Water very salty; 105 feet of pump pipe; small draw-down with strong yield.
5	Great Bend Twp. Great Bend	Newark Milk & Cream Co.	River terrace		135	6		do	155(?)		45	do	Small draw-down pumping 45 gallons a minute; see analysis 5; temperature 52° F., July 21, 1930; bedrock overlain by 40 feet of glacial outwash.
6	Oakland Twp. Oakland	Oakland Water Co.	Near hill-hilltop		266	6		do			89	P S	Auxiliary to spring supply.
7	do	do	do		400	8		do			15	do	D

8	do	do	River terrace	-----	22	4	Outwash gravel	Glacial drift	22	-----	164	do	Auxiliary to spring supply; see analysis 8; temperature 51° F. July 21, 1930.
	Thompson Twp.												
9	Starrucca	Dairymen's Co-operative Association	Hillside	-----	420	8	Sandstone	Catskill	100	100±	-----	I	
10	Thompson	Borden's Creamery	Upland	-----	200	-----	-----	do	-----	50±	20±	do	
11	do	Thompson Borough Water Co.	do	-----	345	8	Sandstone	do	13	140	-----	P S	Auxiliary, seldom used; 180 feet of pump pipe; water reported to be harder than spring nearby.
	New Milford Twp.												
12	New Milford	Sheffield Farms Co.	Valley	-----	80	6	Gravel	Glacial drift	80(?)	20±	-----	I	Small draw-down; air lift; city water supply used for peak loads.
	Bridgewater Twp.												
13	Heart Lake	-----	Upland	-----	125	6	-----	Catskill	40±	-----	-----	D	Water level 5 feet above lake level.
14	do	-----	do	-----	109	6	-----	do	40±	-----	-----	do	Water level 8 feet above lake level.
15	do	Borden's Creamery	do	-----	125	6	-----	do	-----	60±	8.8	I	Small draw-down pumping 8.8 gallons a minute for 3 hours; see analysis 15; spring used as auxiliary.
16	Montrose	do	do	-----	165	6	-----	do	-----	20-30	30±	do	See analysis 16.
17	do	Carlton Farm	Hilltop	-----	35	-----	Drift	Glacial drift	-----	5.89	-----	N	Depth to water level measured July 15, 1930; see pl. 4.
18	South Montrose	South Montrose Creamery	Upland	-----	417	5	-----	Catskill	-----	60	20	I	Small draw-down pumping 20 gallons a minute for 17 hours; see analysis 18; temperature 51° F., July 22, 1930.
19	do	E. H. Ingraham	do	-----	101	6	Sandstone	do	60	23	10	D	Small draw-down pumping 10 gallons a minute.
20	do	W. E. Lott	do	-----	103	6	do	do	40(?)	14	-----	do	On south side of street wells average 100 feet deep and 40 feet to bedrock; north side of street is higher, but wells average 50 feet deep and 20 feet to bedrock.

Drilled wells in Susquehanna County—Continued

No.	Location ¹	Owner or tenant	Topographic situation	Altitude above sea level (feet) ²	Depth (feet)	Diameter (inches)	Character of water-bearing material	Geologic horizon	Depth of casing (feet)	Depth to water level (feet)	Yield (gallons a minute).	Use of water ³	Remarks
21	South Montrose Forest Lake Twp.	A. L. Lake	Upland	-----	20	-----	Drift	Glacial drift	-----	4	-----	D	Adequate supply.
22	$\frac{1}{2}$ mile north of Forest Lake Jessup Twp.	Rosedale Dairy Co.	Edge of valley	-----	90±	4	-----	Catskill	-----	-----	-----	I	Adequate supply; see analysis 22.
23	Fairdale Rush Twp.	Woodlawn Farm Dairy	do	-----	157	8	Sandstone(?)	do	-----	26	large	do	Somewhat low in summer.
24	$\frac{1}{2}$ mile northeast of Lawton	-----	do	-----	24±	-----	Drift	Glacial drift	-----	-----	-----	D	Low in summer.
25	Rush	Mr. VanDyke	do	-----	70	-----	-----	Chemung	-----	-----	-----	do	Adequate supply.
26	$\frac{3}{8}$ mile southwest of Rush Dimock Twp.	H. J. Light	Hillside	-----	166	6	-----	do	-----	50-60	-----	do	Do
27	Dimock	Mr. Norris	-----	-----	452	6	-----	Catskill	-----	180±	-----	do	
28	do	Creamery	-----	-----	385	8	-----	do	20±	70	-----	1	
29	do	-----	-----	-----	579	8	-----	Chemung(?)	20±	70	-----	do	

30	$2\frac{1}{2}$ miles south of South Montrose	P. Ballyntine	Near hill-top	598	8		do			40±	I & D	Pump at 260-foot depth; also uses two other drilled wells and several springs; see analysis 30; temperature 52° F., July 22, 1930.
	Brooklyn Twp.											
31	Kingsley	P. Wilmarth	Steep hill side	198	6	Blue-gray sandstone	Catskill	1-2(?)		10	I	Small draw-down pumping 25 gallons a minute; first water at 100 feet; 90 feet of 4-inch pump pipe; see analysis 31; temperature 50° F., July 21, 1930.
32	do	Delaware Lackawanna & Western R. R.	Hillside	450	12	Red and green sandstone	do		58½	34	R	Small draw-down pumping 34 gallons a minute for 9 hours; see log. Well was later deepened to 668 feet without appreciable change.
33	do	do	do	500	12	do	Chemung			50	N	Abandoned because the water causes foaming in boilers; see log; later deepened to 627 feet without change.
	Harford Twp.											
34	Kingsley	do	do	318	10	do	Catskill	150	60±		R	Used only as auxiliary to surface supply.
35	do	Mary Engate	do	90	6	Blue-gray sandstone	do	14	40		D	Adequate supply; drift 14 feet, red shale 14 feet; blue-gray sandstone 62 feet.
36	Near Tingley Lake	A. J. Masters	Lakeside	50	6		do		5	Very small	do	Large draw-down; water reported to be cloudy.
37	do	A. W. Crossman	do	265			do		5		do	
38	Harford	Rosedale Dairy Co.	Hillside	175	6		do		5	13	I	Can be pumped dry at 13 gallons a minute; see analysis 38; temperature 50° F., July 21, 1930.
	Gibson Twp.											
39	Gibson	F. W. Barret		25			do		20±		D	Dug well.
40	do	Gibson Dairy Association	Valley	120	6		do	30	Flows	30	I	Flowed 1.1 gallons a minute; water level 18 inches above surface, July 15, 1930; draw-down 20± feet pumping 30 gallons a minute all day; temperature 51° F.
41	Union Hill (?)			420	6		do	20	70		D	

Drilled wells in Susquehanna County—Continued

No.	Location ¹	Owner or tenant	Topographic situation	Altitude above sea level (feet) ²	Depth (feet)	Diameter (inches)	Character of water-bearing material	Geologic horizon	Depth of casing (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
42	²³ / ₄ miles north-east of South Gibson	H. D. Cole	Valley	-----	108	6	-----	Catskill	108(?)	48	2	D	
43	do	W. W. Ressegue	do	-----	125	6	Sandstone	do	18	25	7	do	Small draw-down pumping 7 gallons a minute for 1 hour and 45 minutes; first water at depth of 50 feet.
44	²³ / ₄ miles north-east of South Gibson	E. L. Davis	Top of knoll	-----	84 ¹ / ₂	6	Blue sandstone	do	64	30	10	do	Small draw-down pumping 10 gallons a minute for 10 minutes.
45	South Gibson	-----	Hillside	1,000	160	8	-----	do	8-10	90±	-----	do	Supplies 5 families; also use spring.
	Clifford Twp.												
46	Dundaff	Mrs. Jones	Upland	1,640	176	5 ¹ / ₂	-----	do	4	90±	15-20	do	Small draw-down pumping 15 to 20 gallons a minute.
47	¹³ / ₄ miles south-east of Dundaff	do	do	1,780	350	8	Sandstone	do	125	80	3	do	Large draw-down pumping 3 gallons a minute; well unfinished.
	Lathrop Twp.												
48	Hopbottom	Sheffield Farms Co.	Edge of valley	-----	257	6	do	do	30-40	35-40	-----	I	Pumps 3-inch pipe full; water is chlorinated.
49	do	Hopbottom Water Co.	Valley	-----	120	-----	-----	do	-----	20±	-----	P S	Used only as an auxiliary supply.
	Springville Twp.												
50	Springville	Dairymen's Cooperative Association	Edge of low hill	-----	300	6	-----	do(?)	-----	30±	-----	I	Has another deep well.

51	do		Hillside		4	96±	Drift(?)	Glacial drift		3±	3-9	S	Dug well; flowed 9.1 gallons a minute July 14, 1930 (after heavy rain); 3.7 gallons a minute July 22, 1930 (see p. 264); see analysis 51.
	Auburn Twp.												
52	Auburn Center	Dairymen's Cooperative Association	Upland		160	6		Chemung		60±	7.5	I	See analysis 52; temperature 52° F., July 22, 1930.
53	¾ mile south-west of Retta Lanesboro ¹	R. W. Marboher	Near hill-top		65±	6		do				D	Reliable.
	do ¾ mile west of	E. S. Terrell	Hillside	980	169	6	Shale	Chemung	33	47	6	D	5 feet to rock.
	do do	Jas. McGinty	Riverflat	910	80	6	Sandstone	do	77	20		do	
	do do	C. F. Beebe	Riverflat	910	41	6	do	do	36	16		do	
	do do	R. Chidester	Kame	940	141	4	do	do	132	20		do	Serves 4 families.
	do 1½ miles north of	George Kosinsky	Riverflat	940	102	6	do	do	95	32		do	
	do 1½ miles north of	Clifford Loeb	Riverflat	920	145	6	do	do	142	12		do	
	Oakland	Oakland Water Co.	Hillside	1090	399	8	Shale	do	111	81	15	P S	
	do	Lewis Regan	do	1010	105	6	Sandstone	do	80	35		D	
	Susquehanna												
	do Washington St. School	School Board	do	1090	481	6	do	do	200	126	15	do	
	do Laurel St. School	do	do	1060	304	8	do	do	121	48	25	do	
	do Laurel Hill Academy		do	1020	70	6	Gravel	Recent	65	Flows		do	
	do	B. R. Tickner	do	1060	110	6	do	do	105	35		do	Serves 2 families.
	do	Jos. Hadlick	do	1010	165	6	Shale	Chemung	95	95	3	do	
	Brushville	Albert Brush	Upland	1546	150	6	Sandstone	Catskill	70			do	
	do	Wm. Deakin	do	1440	137	6	do	do	100	Flows		do	
	Hickory Grove	Hickory Grove Creamery	Riverflat	900	101	6	Shale	Chemung	30	25		I	

¹ If no distance is given well is located in town.

² Generally estimated from nearest contour line or bench mark on topographic map.

³ D—Domestic; I—Industrial; N—None; PS—Public supply; R—Railroad; S—Stock.

⁴ The following 16 records, supplied by D. S. Harding, Susquehanna, are of wells drilled since 1931.

Log of Delaware, Lackawanna & Western Railroad Co.'s wells at Kingsley

Well 32	Feet	Well 33	Feet
Glacial drift (?)	0- 22	Glacial drift	0 - 13.5
Broken sandstone	22- 37	Red shale	13.5- 17.5
Green sandstone	37-112	Green sandstone	17.5-106
Red sandstone	112-144	Gray sandstone	106 -128
Red shale	144-146	Red sandstone	128 -150
Green sandstone	146-256	Green sandstone	150 -258
Red sandstone	256-300	Red sandstone	258 -298
Green sandstone	300-336	Green sandstone	298 -343
Red sandstone	336-358	Red sandstone	343 -366
Green sandstone	358-372	Green sandstone	366 -373
Red sandstone	372-383	Red sandstone	373 -386
Green sandstone	383-450	Green sandstone	386 -435
		Gray sandstone	435 -500

Analyses of waters in Susquehanna County

[Analyst, K. T. Williams. Parts per million. Numbers less than 1200 correspond to numbers on map and in the table of well data]

	5	8	15	16	18	22	30
Silica (SiO ₂)	22	10	--	--	--	13	--
Iron (Fe) .....	.10	.04	--	--	--	3.71	--
Calcium (Ca)	38	10	12 ¹	18 ¹	26	26	28
Magnesium (Mg)	7.5	2.7	--	--	8.0	9.2	8.8
Sodium (Na)	9.6	3.1	} 8 ²	15 ²	6 ²	{ 13	{ 9 ²
Potassium (K) .....	.8	.4					
Carbonate (CO ₃)	0	0	0	7.9	0	6	4.9
Bicarbonate (HCO ₃)	159	26	55	126	102	116	127
Sulphate (SO ₄)	4.8	14	9 ¹	8 ¹	12 ¹	24	4 ¹
Chloride (Cl)	5.0	1.9	--	8.0	4.0	8.0	4.0
Nitrate (NO ₃) .....	.10	.00	2.2	4.2	4.2	1.5	3.3
Total dissolved solids	162	57	74 ²	148 ²	119 ²	151	131 ²
Total hardness as CaCO ₃ (calculated)	126	36	50 ³	106 ³	98	103	106
Date of collection (1930)	July 21	July 21	July 22	July 22	July 23	July 22	July 22

	31	38	51	52	1215 ⁴	1216 ⁴	1217 ⁴
Silica (SiO ₂)	--	--	--	--	--	--	--
Iron (Fe)	--	--	--	--	--	--	--
Calcium (Ca)	20 ¹	35	16 ¹	50	12 ¹	16 ¹	20 ¹
Magnesium (Mg)	--	8.6	--	12	--	--	--
Sodium and Potassium (Na and K)	23 ²	7 ²	11 ²	15 ²	4 ²	11 ²	7 ²
Carbonate (CO ₃)	5.9	0	0	8.0	0	8.9	0
Bicarbonate (HCO ₃)	110	153	55	218	26	42	22
Sulphate (SO ₄)	26 ¹	10 ¹	24 ¹	12 ¹	10 ¹	14 ¹	28 ¹
Chloride (Cl)	6.0	1.0	1.0	1.0	1.0	1.0	2.0
Nitrate (NO ₃) .....	.10	.50	4.3	.10	4.2	1.5	2.4
Total dissolved solids	148 ²	144 ²	87 ²	215 ²	43 ²	73 ²	70 ²
Total hardness as CaCO ₃ (calculated)	86 ³	123	51 ³	174	28 ³	42 ³	42 ³
Date of collection (1930)	July 21	July 21	July 22	July 22	July 21	July 21	July 21

¹ By turbidity.² Calculated.³ Determined.

⁴ 1215. Spring in Thompson; glacial drift; temperature 50°F. 1216. Spring in Kingsley; sandstone of Catskill group; temperature 50°F. 1217. Spring at Halfway Spring House, $\frac{1}{2}$ mile north of Hopbottom; Catskill group; temperature 49°F.

WAYNE COUNTY

GENERAL FEATURES

[Area 739 square miles, population 28,420]

Wayne County occupies the extreme northeast corner of the State and of the area covered by this report and is bounded on the north and east by New York State. The population is largely rural, as the entire county is covered with small farms, and there are only two communities with 1,000 or more inhabitants—Honesdale, 5,490, and Hawley, 1,811. Wayne County had 2,908 farms in 1930, and in 1929 there were only 65 manufacturing establishments in the county whose annual products were valued at \$5,000 or more each. Numerous summer resorts have been built along Delaware River and around the glacial lakes, and Wayne County has become a popular playground for people from New York and New Jersey.

SURFACE FEATURES

The highest part of Wayne County is a narrow strip along the Susquehanna and Lackawanna County lines, where the Moosic Mountains, formed by Pottsville sandstone, rise in several places to altitudes of more than 2,300 feet. Mount Ararat, the second highest peak in northeastern Pennsylvania, is 2,654 feet and Sugarloaf Mountain is 2,541 feet above sea level. Both of the peaks are in the southwest corner of Preston Township. The Moosic Mountain divide continues northward at an altitude of about 2,000 feet. The remainder of the county slopes gently eastward and southeastward toward Delaware River in the northern part and toward Lackawaxen River in the southern part. The lowest point in the county is where Delaware River crosses the Pike County line, at an altitude of about 600 feet. The maximum relief is therefore about 2,050 feet. Locally the greatest relief is found along the deeply incised valleys of Delaware River and its tributaries, which in many places are more than 500 feet deep.

With the exception of small areas along the northern part of the western border, Wayne County is drained entirely by Delaware River, which flows along its eastern border. Lackawaxen River, a tributary of the Delaware, drains the southern part of the county through Pike County, and the northern part drains directly into the Delaware by a number of small streams. Parts of Scott and Preston Townships are drained by Starrucca Creek, a tributary of the North Branch of Susquehanna River; and parts of Preston, Mount Pleasant, Clinton, and Canaan Townships are drained by the Lackawanna. In flowing a distance of 37 miles from Hancock, N. Y. to Milanville, Pa., Delaware River drops 200 feet—a gradient of about 5.4 feet to the mile.

GEOLOGY AND GROUND WATER

GENERAL SECTION

With the exception of the summits of Sugarloaf Mountains and Mount Ararat, Wayne County, was entirely covered by ice during the last glacial stage. Deposits of glacial drift are found all along the streams, cover much of the highlands, and remain on many of the hill slopes

where these are not so steep as to have shed them subsequently. Glacial outwash deposits fill the valleys of Lackawanna River, and its tributaries, causing the gentle fall in Dyberry Creek between Tanners Falls and Honesdale. The old valley of Wallenpaupack Creek south of Wilsonville is filled with glacial drift, but these deposits are now beneath the water of Lake Wallenpaupack. Delaware River, on the contrary, flows over a bedrock channel in most places. Wayne County is dotted with small lakes of glacial origin, many of which are bordered with summer resorts.

The rock formations exposed in Wayne County extend from the Pottsville and post-Pottsville formations down to the Shohola formation of the Catskill continental group. The Pottsville and post-Pottsville formations, the Mauch Chunk shale and the Pocono sandstone are exposed only in a small area in the Moosic Mountains, at the junction of Susquehanna, Wayne, and Lackawanna Counties. With the exception of the small area just described, the entire county is underlain by rocks of the Catskill group.

Generalized section for Wayne County

Geologic formation	Maximum thickness exposed (feet)	Character of rocks	Ground-water conditions
Glacial drift (Wisconsin)	200±	Till and glacial outwash (clay, sand, and gravel).	Yields small supplies of potable water.
Pottsville and Post-Pottsville formations	200+	Conglomerate, sandstone, slate, and coal.	Small areas of outcrop; no wells reported; water-bearing in counties to the south.
Mauch Chunk shale	0—170	Hard gray sandstone, pebbly white sandstone, dark and reddish shale.	
Pocono sandstone	605±	Pebbly conglomerate, gray cross-bedded sandstone, and buff sandy shale.	
Catskill group	1,900±	Red shale and gray cross-bedded sandstone, with some conglomerate, green, red, and white sandstone, gray and olive-green shale, and calcareous breccia.	Yields moderate to large supplies of water of good quality, most important water-bearer in county.

STRUCTURE

The geologic structure of Wayne County is relatively simple. North of Honesdale the rocks are nearly horizontal and dip 20 to 30 feet to the mile. South of Honesdale the rocks appear to be horizontal but in places may rise slightly to the south. The Lackawanna syncline is the only well-defined fold in the county, although there are a few slight rolls of local extent. The rising Lackawanna syncline turns north at the Wayne County line, bringing down the Carboniferous rocks as far north as Sugarloaf Mountain, in Preston Township. This syncline is but a gentle trough at its northern extremity but deepens rapidly as it approaches Carbondale, continuing southwestward to form the Northern anthracite field. The dip of the strata flattens out a short distance to the east of this fold.

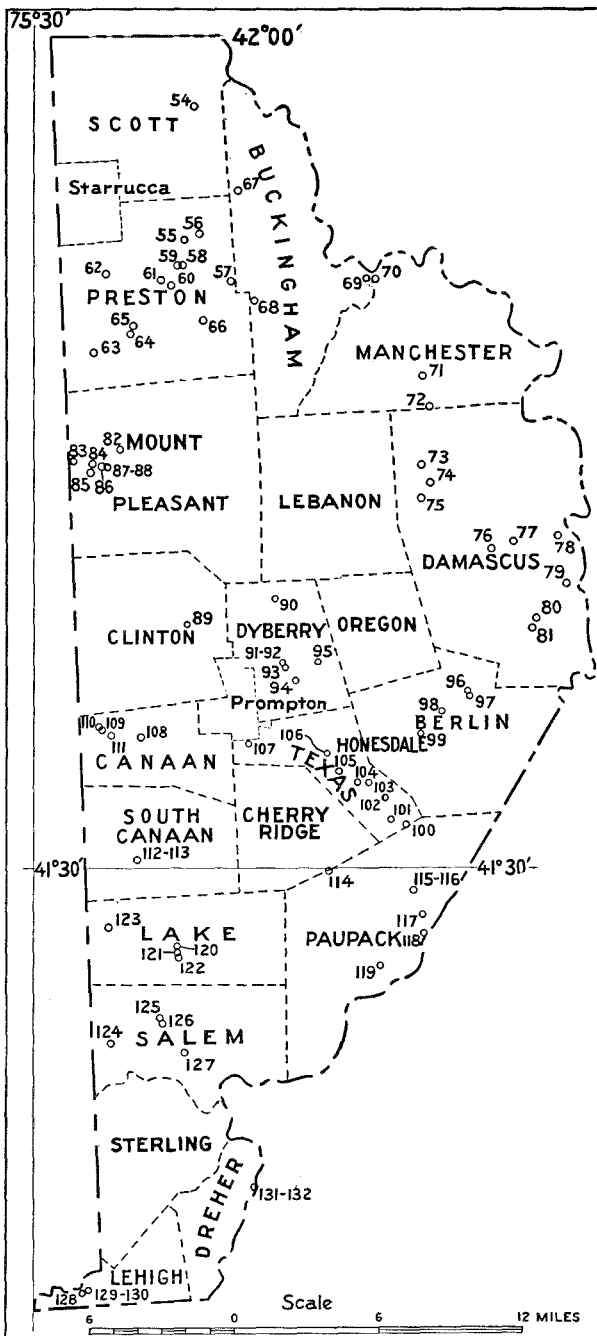


Figure 17. Map of Wayne County showing location of water wells

The name of Palmyra Township north of Paupack and the boundary between them was omitted by error. Well 116 is beside 117.

WATER-BEARING FORMATIONS

[See pp. 41-53 for further description]

Glacial drift.—Most of the domestic supplies of water in Wayne County are obtained from the glacial drift by means of springs and shallow dug and driven wells. Very few drilled wells are reported to end in glacial drift, but many of the drilled wells ending in bedrock are cased through a considerable thickness of drift, and in some places the drift contains more water than the underlying bedrock. (See well 92). In Beach Lake two drilled wells (96 and 97) obtain water from lenses of gravel in the glacial drift at depths of 180 and 212 feet. Although the highest reported yield from wells in the drift is 12 gallons a minute, greater yields could probably be obtained from properly constructed wells in the glacial outwash deposits along Lackawaxen River. The water from the glacial drift is of good quality.

Post-Pottsville, Pottsville, Mauch Chunk and Pocono formations.—The Pottsville formation, Mauch Chunk shale, Pocono sandstone and probably some of the post-Pottsville formations crop out in a small mountainous area in west-central Wayne County where they are unimportant as sources of ground water.

Catskill continental group.—Except for the small area of Carboniferous rocks in the west-central part, all of Wayne County is underlain by the Catskill continental group. The exposed formations of the Catskill range from the Mount Pleasant down to the Shohola at the east and the New Milford at the north.

The Catskill yields moderate to large supplies of very good water in Wayne County. Some of the domestic wells obtain small supplies from the red shale, but all the stronger wells obtain water from sandstone. Several wells are reported to yield 100 gallons a minute or more, and wells 85 and 105 are reported to yield 175 and 140 gallons a minute respectively. A few deep wells encounter some hydrogen sulphide, which is harmless in the small quantities generally obtained.

ARTESIAN CONDITIONS

Owing to the relatively simple structure of the rocks in Wayne County, there are very few flowing wells, but in many wells the water level stands considerably above the point at which water was first encountered. Five flowing wells were reported in the Catskill, but these are scattered over the county so that no areas of flowing wells can be definitely established. In each well the flow is small, and most of the water is obtained by pumping.

QUALITY OF WATER

Analyses of 12 samples of water collected in Wayne County are tabulated on page 278. The analyses of 8 samples from drilled wells in the Catskill and the analyses of 4 samples from wells and springs in the glacial drift indicate an average content of about 100 parts per million of total dissolved solids and an average hardness of about 60 parts per million. The water in all the wells was reported to be entirely satisfactory for most purposes.

The State Fish Hatchery, near Pleasant Mount, uses ground water for

growing trout. An investigation was made in order to determine the suitability of the water so far as dissolved oxygen and carbon dioxide were concerned. Samples of water were collected at the inlet and outlet of the spring, at the outlet of well 84 before and after aeration, and at the discharge into the pond from well 85. The following average results were obtained:

Content of dissolved oxygen and carbon dioxide in ground water at State Fish Hatchery, near Pleasant Mount¹

Source	Temperature (°F.)	Carbon dioxide (parts per million)	Dissolved oxygen	
			Parts per million	Saturation (percent)
Spring -----	45	8	10	83
Well 84 before aeration -----	47	7	13.3	111.5
Well 84 after aeration -----	46	3.5	11.7	97.5
Well 85 at discharge -----	47	2	5.5	46.5

¹ Investigated March 1, 1930, by Paul Rogers, chemist, Pennsylvania Department of Health.

Although the two drilled wells are of nearly the same depth and are only 1,600 feet apart, the water from one well is supersaturated with oxygen and that from the other well has a deficiency of oxygen. The water from the spring was not sufficiently saturated. For growing trout, a nearly saturated water is desirable. The supersaturation of dissolved oxygen in the water from well 84 was removed by allowing the water to splash over an aerator of umbrella type, producing water with a dissolved-oxygen saturation of 97.5 per cent. The carbon dioxide content was likewise reduced about 50 per cent. It was also found that the deficiency in oxygen in the water from well 85 could be made up by aeration and that a mixture of aerated well water and spring water was entirely satisfactory for growing trout.

PUBLIC SUPPLIES

The six public supplies in Wayne County using ground water are tabulated below. Honesdale, the largest borough in the county, is supplied by surface water from several small glacial lakes, most of which are spring-fed from the sides and bottom. Hawley and Waymart are the largest boroughs using ground-water supplies. Individual wells and springs supply most of the villages.

INDUSTRIAL SUPPLIES

At least 9 creameries in Wayne County use ground water for washing, cooling and boiler feed, two of which obtain water entirely from springs. The State Fish Hatchery near Pleasant Mount uses ground water from drilled wells and a spring for trout growing. Other users of ground water include the State Hospital near Waymart and several textile mills in White Mills.

DOMESTIC SUPPLIES

Dug wells and small springs are the chief sources of domestic water supply in Wayne County, though many drilled wells are used. Some of

the dug wells were reported to be very low during the summer of 1930. Dug wells that are not properly located with respect to sources of contamination are not to be regarded as safe supplies. The safest type of well is undoubtedly the drilled well, and nearly all the wells put down in recent years have been drilled.

Analyses of waters in Wayne County

[Parts per million. Numbers less than 1200 correspond to numbers on Map and in the table of well data]

	56	58	63	67	96	105
Silica (SiO ₂)						13
Iron (Fe)						.01
Calcium (Ca)		27	11 ¹	24 ¹		28
Magnesium (Mg)		7.2				4.8
Sodium (Na)		1 ²	13 ²	16 ²		26
Potassium (K)						2.4
Bicarbonate (HCO ₃)	102	112	117	108	141	104
Sulphate (SO ₄)	7 ¹	3 ¹	3 ¹	3 ¹	2 ¹	23
Chloride (Cl)	4.0	3.0	1.0	22	2.0	20
Nitrate (NO ₃)		.60	1.8	.10		3.0
Total dissolved solids	101 ²	103 ²	106 ²	130 ²	124 ²	176
Total hardness as CaCO ₃ (calculated)		97	74 ³	88 ³		90
Date of collection (1930)	Sept. 19	Sept. 19	Sept. 19	Sept. 19	Sept. 20	Sept. 19

	108	117	128	131	1218 ⁴	1219 ⁴
Silica (SiO ₂)	12		7.2			13
Iron (Fe)	.01		.01			.01
Calcium (Ca)	24	7 ¹	15	7 ¹	32 ¹	10
Magnesium (Mg)	3.5		5.5			4.7
Sodium (Na)	8.9	4 ²	1.9	1 ²	7 ²	5.7
Potassium (K)	.9		1.8			1.1
Bicarbonate (HCO ₃)	99	34	64	25	21	22
Sulphate (SO ₄)	5.0	6 ¹	6.2	14 ¹	74	10
Chloride (Cl)	3.2	3.0	3.0	4.0	1.0	9.0
Nitrate (NO ₃)	1.2	.50	.50	2.4	8.0	20
Total dissolved solids	112	42 ²	75	50 ²	134 ²	77
Total hardness as CaCO ₃ (calculated)	74	30 ³	60	40 ³	87 ³	44
Date of collection (1930)	Sept. 19	Sept. 20	Sept. 20	Sept. 20	Sept. 19	Sept. 19

¹ By turbidity. ² Calculated. ³ Determined.

⁴ 1218. Spring in Starrucca; glacial drift; temperature 53°F. 1219. Spring in Hamlin; glacial drift; temperature 50°F.

Analysts: 56, 96, 105, 108, 117, 128, 1219, L. A. Shinn; 58, 63, 67, 131, 1218 K. T. Williams.

Public water supplies in Wayne County derived from ground water

Place	Population 1930 ¹	Owner	Source	Geologic source	Storage (gallons)	Average daily con- sumption (consumers)	Treatment	Remarks
Aldenville	-----	G. H. Knap	2 springs	Glacial drift	30±	10	None	
Gouldsboro	76	T. R. Harvey	1 drilled well	Catskill	25,000±	76	None	See analysis and well 128.
Hamlin	-----	R. F. Spangenburg	4 springs (2 used)	Glacial drift	1,000	9	None	See analysis 1219.
Hawley	1,811	Hawley Water Co.	2 lakes, 4 springs, and 2 drilled wells	Springs in glacial drift. Wells in Catskill.	5,100,000	400	Surface water chlorinated	See wells 116, 117, analysis 117.
Starrucca	351	C. T. Glover	1 spring	Glacial drift	13,000	6	None	See analysis 1,218.
Waymart	902	Waymart Water Co.	7 or 8 springs and 2 drilled wells	Springs in glacial drift. Wells in Catskill.	-----	201 ²	Spring water chloride of lime	See analysis and well 108.

¹ Figures available only for incorporated places.² Includes one creamery.

Drilled wells in Wayne County

No.	Location ¹	Owner or tenant	Topographic situation	Altitude above sea level (feet) ²	Depth (feet)	Diameter (inches)	Character of water-bearing material	Geologic horizon	Depth to which water is cased (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
54	Scott Twp. $2\frac{1}{4}$ miles west of Winterdale	Camp Seodale	-----	-----	171	8	Sandstone	Catskill	107±	90	20	D	Draw-down 25 feet pumping 20 gallons a minute; first water at 135 feet, second at 171 feet.
55	Preston Twp. $\frac{1}{2}$ mile south west of Preston Park	A. O. Stanton	Hillside	-----	65	6	-----	do	12	20	4	do	Small draw-down pumping 4 gallons a minute.
56	Preston Park	Dairymen's Cooperative Association	Valley	-----	200	8	-----	do	20	50	37	I	See analysis 56; temperature 50° F. Sept. 19, 1930.
57	Lake Como	Mr. Mahoney	-----	-----	134	6	Red sandstone	do	20	54	5	D	Small draw-down pumping 5 gallons a minute for 1 hour.
58	Lakewood	Dairymen's Cooperative Association	Hillside	-----	397	8	Gray sandstone	do	20	197	16	I	Small draw-down pumping 16 gallons a minute for 10 hours; see analysis 58; temperature 49°F. Sept. 19, 1930.
59	Near La'ewood	Camp Geneva	-----	-----	486	8	-----	do	110	100	Weak	D	Draw-down 200 feet pumping 30 gallons a minute; exact location not known.
60	$\frac{1}{4}$ mile south of Lakewood	Mr. Honsfeld	Hilltop	-----	147	6	Sandstone	do	4	67	8	do	Large draw-down pumping 8 gallons a minute for 1 hour.
61	$\frac{1}{2}$ mile west of Lakewood	George Flynn	do	-----	280	6	Gray sandstone	do	72	140	15	do	Small draw-down pumping 15 gallons a minute for 15 hours
62	$\frac{1}{4}$ miles east of Preston Center	G. Carpenter	do	-----	178	6	-----	do	70	100	10	do	Small draw-down pumping 10 gallons a minute for 2 hours.
63	$\frac{3}{4}$ mile north-east of Orson	Dairymen's Cooperative Association	Valley	-----	240	8	Gray sandstone	do	146	140	40	I	Small draw-down pumping 40 gallons a minute for 10 hours; see analysis 63; temperature 50°F. Sept. 19, 1930.
64	Poyntelle	-----	-----	-----	337	6	do	do	-----	100	-----	-----	Exact location not known.
65	do	Mr. Tully	Hillside	-----	210	6-4	Red and gray sandstone	do	100	80	10	-----	Small draw-down pumping 10 gallons a minute.

66	0.6 mile north of Preston Buckingham Twp.	Mrs. Fury	Valley	-----	100	6	Hard gray sandstone	do	8	20	5	-----	Small draw-down pumping 5 gallons a minute.
67	Starlight	Sheffield Farms Co.	Hillside	-----	629	6	Red and gray sandstone	do	-----	At surface	-----	I	Water reported to be hard; some hydrogen sulphide; see analysis 67, temperature 51°F. Sept. 19, 1930.
68	1½ miles southeast of Lake Como	Camp Winona	do	-----	668	-----	do	do	8-9	30	5	D	Draw-down 170 feet pumping 5 gallons a minute for 1 hour.
69	½ mile west of Equinunk Manchester Twp.	J. S. Warfield	Valley	878	33	1½	Sand and boulders	Glacial drift	33	17	-----	do	Driven well.
70	Equinunk	Bleck Hotel	do	900±	74	6	-----	Catskill	-----	-----	-----	do	Small draw-down pumping 10 gallons a minute for 1 hour.
71	1.1 miles north of Lookout	R. G. Lumberick	Canyon	1,280	176	8-6	-----	do	136	50	10	do	
72	½ mile north of Hilltown Damascus Twp.	Harris Hill	do	1,160	90-100	6	"Quicksand"	Glacial drift	90-100	-----	small	do	
73	1½ mile north of Rutledge-dale	Arnold Rutledge	Hilltop	1,480	216	6	-----	Catskill	6	161	4-5	do	Large draw-down pumping 4 to 5 gallons a minute for half an hour.
74	½ mile northeast of Rutledge-dale	Ames Rutledge	Hillside	1,400	133	-----	-----	do	-----	60	-----	do	
75	1½ miles southwest of Rutledge-dale	Tilden Rutledge	do	1,345	30	-----	-----	do	-----	24	-----	do	Water stands 10 feet below the surface in wet weather.
76	1 mile west of Tyler Hill	Camp Mitchell	Hilltop	1,300	265	6	Red shale	do	8	30	8	do	Large draw-down pumping 8 gallons a minute for 1 or 2 hours.
77	Tyler Hill	Mr. Fordman	do	1,300	165	6	Gray sandstone	do	shallow	30-40	-----	do	Red shale overlies gray sandstone.
78	Damascus	Damascus School	Hillside	860	532	6	Gray and red sandstone	do	10	-----	4	do	Moderate draw-down pumping 4 gallons a minute; water slightly milky.

Drilled wells in Wayne County—Continued

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No.	Location ¹	Owner or tenant	Topographic situation	Altitude above sea level ² (feet)	Depth (feet)	Diameter (inches)	Character of water-bearing material	Geologic horizon	Depth to which well is cased (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
79	Milanville	Mr. Gable	Valley	740	126	6	Outwash sand	Glacial drift	126	15±	12	D	Small draw-down pumping 12 gallons a minute for 40 hours; finished with a screen; water turbid.
80	2 miles southwest of Milanville	Henry Helms	Hilltop	1,220	96	-----	-----	Catskill	6-8	80—	5±	do	80 feet of pump pipe.
81	2½ miles southwest of Milanville	Dr. Poor	Hillside	1,260	254	8	-----	do	8	87	9	do	Small draw-down pumping 9 gallons a minute for 44 hours.
	Mount Pleasant Twp.												
82	1¼ miles northeast of Pleasant Mount	Mr. Harris	do	-----	113	6	Red shale	do	40	73	10	do	Small draw-down pumping 10 gallons a minute.
83	1¼ miles west of Pleasant Mount	Mr. Minowsky	do	2,100	178	6	Gray sandstone, some red shale	do	100	78	10	do	Do
84	½ mile west of Pleasant Mount	State Fish Hatchery	Valley	1,820	560	8	-----	do	30	8	125	F	Well 1, draw-down 32 feet pumping 125 gallons a minute for 24 hours; see discussion of oxygen content on pp. 276, 277.
85	do	do	do	1,820	420	6	-----	do	-----	15	175	do	Well 2, 1,600 feet southwest of well 1, draw-down 32± feet pumping 175 gallons a minute for 24 hours; see discussion of oxygen content on pp. 276, 277.
86	Pleasant Mount	Mrs. Murray	Hilltop	2,020	130	4	Gray sandstone	do	26	60	5	D	Small draw-down pumping 5 gallons a minute.
87	do	Mr. Corby	do	2,020	118	6	do	do	8	60	10	do	Small draw-down pumping 10 gallons a minute for 2 hours.
88	do	J. LaStrange	Hillside	-----	80	6	Red shale	do	12	40±	10	do	Small draw-down pumping 10 gallons a minute.

Clinton Twp.													
89	0.4 mile north-west of Alden-ville	Joseph Koslosky	Hilltop	1,460	140	-----	-----	do	shallow	6	-----	do	Small draw-down.
Dyberry Twp.													
90	Tanners Falls	Ralph Tigler	-----	-----	250	-----	Red shale	do	10	100	6	do	Large draw-down pumping 6 gal- lons a minute.
91	1 mile north-west of Bethany	N. Kahan	do	1,580	306	6	-----	do	-----	35	6	do	Draw-down 125 feet pumping 6 gallons a minute.
92	do	do	do	1,560	700	8	Red shale	do	60	20	3	do	Large draw-down pumping 3 gal- lons a minute; casing later pulled up to allow entrance of water in drift; yield increased to 25 gallons a minute with draw-down of 15 feet pumping 6 days; now has draw-down of 30 feet pumping 10 gallons a minute for 1 hour; decrease may be due to caving in of the drift.
93	$\frac{1}{2}$ mile north-west of Bethany	do	Hillside	1,520	275	6	-----	do	-----	100	20	do	Draw-down 100 feet pumping 20 gallons a minute for 3 hours.
94	Bethany	B. D. Miller	do	-----	450	10	Red shale	do	246	50	-----	do	Drift 246 feet, blue rock 40 feet, red shale 164 feet; draw-down 100 feet pumping 90 gallons a minute at a depth of 150 feet.
95	$\frac{1}{2}$ mile south-west of Dy- berry	Mr. Eck	do	1,000	165	-----	Blue sand- stone and red shale	do	0-40 52-71	30	12	do	
Berlin Twp.													
96	Beach Lake	W. H. Dunn	Hilltop	1,260	180	6	Gravel	Glacial drift	180	105±	-----	do	"Quicksand" from 60 to 70 feet; first water at 75 feet; water reported to be hard; see an- alysis 96; temperature at out- let 63°F. Sept. 20, 1930.
97	do	F. Craig	do	1,240	212	6	do	do	212	-----	10	do	Water reported to be soft; "hard- pan" 40 feet; "quicksand" 30 feet, boulders at 85 feet.
98	Lake $\frac{1}{2}$ miles south-west of Beach	E. E. Avery	do	1,440	149	6	Gray sand- stone	Catskill	shallow	89±	-----	do	All red shale except gray sand- stone bed at bottom.

Drilled wells in Wayne County—Continued

No.	Location ¹	Owner or tenant	Topographic situation	Altitude above sea level ² (feet)	Depth (feet)	Diameter (inches)	Character of water-bearing material	Geologic horizon	Depth to which well is cased (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
99	$2\frac{1}{4}$ miles south-west of Beach-Lake Texas Twp.	Honesdale Airport	Hillside	1,440	209	6	Red sandstone	Catskill	4	75	15	D	Small draw-down pumping 15 gallons a minute for $1\frac{1}{2}$ hours.
100	White Mills	Wellwood Improvement Co.	do	1,000	213	6	Blue-gray sandstone	do	20	flows	50	I	Draw-down 15 feet pumping 15 gallons a minute for 1 hour; also encountered red shale and conglomerate.
101	do	J. C. Wellwood Mill	do	980	266	6	Blue sandstone	do	130	4	117±	do	Draw-down $\frac{3}{4}$ -inch pumping 117 gallons per minute for 12 hours.
102	Indian Orchard	A. Seaman	Valley	980	70	6	Sandstone	do	12-15	30±	3—	D	Large draw-down pumping 3 gallons a minute for 15 minutes.
103	$\frac{3}{4}$ mile north-west of Indian Orchard	do	do	980	85	6	do	do	5	40	4-5	do	Small draw-down pumping 4 to 5 gallons a minute.
104	$\frac{3}{4}$ mile south-west of East Honesdale	Mr. Snyder	do	1,000	148	6	Red "rock"	do	100	-----	15	do	
105	East Honesdale	Dairymen's Cooperative Association	do	980	238	6	Red and gray sandstone	do	90	0-2	140	I	Small draw-down pumping 140 gallons a minute; see analysis 105; temperature 52°F. Sept. 19, 1930.
106	Honesdale	W. H. Burkhardt	Hillside	1,000±	92	6	-----	do	20	62	-----	D	
107	Prompton Canaan Twp.	Woodlawn Dairy Co.	Valley	1,100	247	8	-----	do	123	flows	70	N	Draw-down 24 feet pumping 70 gallons a minute for one day.
108	Waymart	Waymart Water Co.	do	1,460	302	6	-----	do	-----	-----	large	P S	See analysis 108; temperature 50°F. Sept. 19, 1930; also has a well 160 feet deep nearby.
109	$1\frac{1}{2}$ miles west of Waymart	State Hospital	Hillside	1,950	180±	4	-----	do	-----	80±	small	H	Large draw-down.

110	1½ miles west of Waymart	do	do	1,950	256	6	-----	do	-----	Above surface to 200 below	60	do	Flows after heavy rain; draw-down 100± feet pumping 60 gallons a minute for 2 weeks; pumping lowers a spring nearby.
111	1½ miles west of Waymart	do	do	1,900	200	6	-----	do	-----	10	small	do	Large draw-down.
112	South Canaan Twp.	G. W. Dersheimer	do	1,400±	276	6	-----	do	-----	157	90	D	Large draw-down; water reported to be hard; water level fluctuates.
113	do			1,400	60	6	-----	do	-----	20-25	20-30	do	
114	Cherry Ridge Twp.	Clemon Heights Fishing Club	do	1,200±	125	6	-----	do	-----	shallow	-----	do	Pumps dry pumping 1 gallon a minute for 20 minutes.
115	Palmyra Twp. ¾ mile north of Hawley	Fred C. Tyce	Valley	920	17.1	24	Sand and gravel	Glacial drift	17.1	15.2	-----	N	Dug well; depth to water level measured Sept. 16, 1931; see pl. 4.
116	Hawley	Hawley Water Co.	do	-----	157	-----	Blue sandstone	Catskill	10-15	32	27	P S	Small draw-down pumping 27 gallons a minute continuously.
117	do	do	Hillside	1,100±	210	-----	do	do	10-15	21	20	do	Small draw-down pumping 20 gallons a minute continuously; see analysis 117; temperature 48°F. Sept. 20, 1930.
118	1 mile south of Hawley	Roosevelt Inn	do	1,200±	147	6	190-147 feet, sandstone	do	10	40	20	D	Small draw-down pumping 20 gallons a minute.
119	Paupack Twp. 3 miles south-west of Hawley	Ed Miller	Lake shore	1,220	224	6	220-224 feet, sandstone	do	45	45	20	do	Do
120	Lake Twp. Lake Ariel	-----	do	1,430±	49	6	Blue sandstone	do	5	8	-----	do	Small draw-down pumping 15± gallons a minute.
121	½ mile south of Lake Ariel	-----	do	1,420±	135	6	-----	do	32	32	15±	do	
122	¾ mile south of Lake Ariel	Hotel Ariel	Hillside	1,460	90±	6	-----	do	50	20±	5	do	
123	1 mile east of Cortez	H. Merring	do	1,560±	66	6	-----	do	-----	-----	-----	-----	
124	Salem Twp. Hollisterville	G. Hollister	Valley	-----	64	6	Gray sandstone	do	22	flows	20	D	

Drilled wells in Wayne County—Continued

No.	Location ¹	Owner or tenant	Topographic situation	Altitude above sea level ² (feet)	Depth (feet)	Diameter (inches)	Character of water-bearing material	Geologic horizon	Depth to which well is cased (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
125	Hamlin	Episcopal Rectory	Upland	1,540	132	6	Gray sandstone	Catskill	96	40±	5	D	First water at 15 feet; small draw-down pumping 5 gallons a minute for 1 hour.
126	do	Mr. Chapman	do	1,574	90	6	Red shale	do	75	40	5	do	Moderate draw-down pumping 5 gallons a minute.
127	$\frac{1}{2}$ mile north of Bidwell Hill	Jesse Lyman	Hillside	1,520	109	6	-----	do	82	40±	1.25	do	Draw-down 60 feet pumping 1½ gallons a minute for 20 minutes.
	Lehigh Twp.												
128	Gouldsboro	T. R. Harvey	Hilltop	1,960	310	10	-----	do	50	37 to 75±	33	P S	Small draw-down pumping 33 gallons a minute for 4 hours; see analysis 128; temperature, 48° F. Sept. 20, 1930; water level 37 feet below surface Sept. 13, 1930; highest ever recorded.
129	do	W. L. Harvey	Upland	1,860	103	6	Sandstone	do	50	1-2	small	N	Considerable draw-down; occasionally flows.
130	do	H. A. Reiling, Inc.	do	1,920	200	10	-----	do	13	17±	25	I	Water reported to be hard.
	Dreher Twp.												
131	Newfoundland	Dairymen's Cooperative Association	Valley	1,320	28	2	Sand and gravel	Glacial drift	28	15-16	10	do	Driven well; small draw-down pumping 10 gallons a minute for 24 hours; see analysis 131; temperature 59.5° F. Sept. 20, 1930.
132	Near Newfoundland	Mr. Brown	Hillside	-----	60	6	Gray sandstone	Catskill	shallow	5	2	-----	Large draw-down pumping 2 gallons a minute.

¹ If no distance is given well is located in town.² Generally estimated from nearest contour line or bench mark on topographic map.³ D—Domestic; F—Growing fish; H—Hospital; I—Industrial; N—None; PS—Public supply.

WYOMING COUNTY

GENERAL FEATURES

[Area 397 square miles, population 15,517]

Wyoming County lies in the northwest part of the area described in this report and is bordered on the west by Bradford and Sullivan Counties. The population is largely rural, and Tunkhannock, with 1,973 inhabitants in 1930, is the only borough in the county having 1,000 or more. In 1930 there were 1,409 farms in Wyoming County, and in 1929 the county had 27 manufacturing establishments whose annual products were valued at \$5,000 or more each.

SURFACE FEATURES

Southwest of Susquehanna River the surface rises rapidly to the high plateau of North Mountain, lying 2,100 to 2,200 feet above sea level and containing peaks that reach 2,400 feet. This high plateau, broken only by the deep gorges of Mehoopany and Bowman Creeks, is at its highest point about 1,830 feet above the lowest point (570 feet) on Susquehanna River, where it leaves the county. The high and rugged North Mountain, extending westward into Sullivan County, is densely forested and is one of the wildest parts of the State. Except for several small isolated peaks below Tunkhannock the remainder of Wyoming County northeast of Susquehanna River and below North Mountain is composed of softer rocks which have been eroded into a series of rounded hills with comparatively gentle slopes, except along the larger streams, where the slopes in some places are vertical. Northeast of the Susquehanna few of the hills rise to more than 1,200 feet above sea level.

Wyoming County is drained entirely by the North Branch of Susquehanna River, which meanders diagonally through the county, entering at the northwest corner and leaving at the southeast corner. The principal tributaries are Mehoopany, Bowman and Tunkhannock Creeks. The Lehigh Valley Railroad parallels the North Branch of the Susquehanna through the county and has about the same gradient as the river. Between Laceyville and Falls, a distance of 37 miles, the railroad drops 71 feet—a gradient of about 1.9 feet to the mile.

GEOLOGY AND GROUND WATER

GENERAL SECTION

Wyoming County lies well to the north of the southern limit of Wisconsin glaciation. It is not certain, however, that the ice covered the entire county, for White¹ concludes from the absence of any traces of glaciation on Millers Mountain, below Tunkhannock, and the high plateau of North Mountain, in Forkston Township that probably these areas were islands protruding above the ice. Elsewhere except in places where erosion has exposed the hard rock formations, the county is covered by glacial drift. The prevailing direction of ice movement, as

¹ White, I. C., The geology of the Susquehanna River region in the six counties of Wyoming, Lackawanna, Luzerne, Columbia, Montour and Northumberland: Pennsylvania Geol. Surv. 2d ser., Rept. G7, p. 13, 1883.

indicated by striae on bare rock exposures, was S.30°—45°W. After the retreat of the ice a vast amount of material was transported by the swollen rivers, much of which was dropped at numerous places along the larger streams. Thus, in many places, the present streams flow over buried valleys and in some places they cut a series of terraces into the thick deposits of glacial outwash.

The rock formations exposed in Wyoming County range from the Pottsville down to the Chemung formation. The youngest formations, the Pottsville formation, Mauch Chunk shale and Pocono sandstone, are preserved from erosion only in a small area in the southwest part of the county where they form the cap rocks of the high North Mountain and some of its isolated outliers, such as Millers Mountain. The oldest rocks of the Chemung formation crop out only in the northwest corner of the county along the North Branch of Susquehanna River. The remainder and by far the greater part of the county is underlain by rocks belonging to the Catskill continental group.

Generalized section for Wyoming County

Geologic formation	Maximum thickness exposed (feet)	Character of rocks	Ground-water conditions
Glacial drift (Wisconsin)	200±	Till and outwash; clay, sand, gravel, and boulders	Till yields small supplies of potable water to dug wells and springs, stratified outwash yields moderate to large supplies of potable water to dug and drilled wells. Water very soft.
Pottsville formation	28½±	Pebbly massive conglomerate underlain by 3½ feet of coal and slate.	
Mauch Chunk shale	150±	Chiefly red shale, but the interval is largely concealed	Not important as sources of ground-water, no wells known to penetrate these formations within the county.
Pocono sandstone	530±	Massive basal conglomerate 46 feet thick, overlain by "slaty" and yellow sandstone, largely massive, greenish-gray sandstone, and red shale, with a few beds of conglomerate, blue, green, and gray sandstone and shale.	
Catskill group	1,750±	Chiefly red and green cross-bedded massive sandstone and red shale, with a few beds of conglomerate, blue, green, and gray sandstone and shale	Yield moderate to large supplies of potable water.
Chemung formation	475±	Greenish gray sandstone; blue, gray, and green shale; dark sandy shale. Only the uppermost beds exposed. Includes some post-Chemung marine beds	Yields small to moderate supplies of water. Water likely to be salty, especially in deep wells.

STRUCTURE

In general the rocks of Wyoming County are practically horizontal, as there are no major folds. There are a number of minor anticlines and synclines, however, most of which trend in a northeasterly direction. At the northwest corner of the county the Wilmot anticline crosses the North Branch of Susquehanna River at Skinners Eddy, bringing up the top of the Chemung formation. The axis trends about N.65°E., and the dips on both sides are gentle, not exceeding 5° or 6°. The eastern extension of the Bernice syncline passes across the top of Dutch Mountain in North Branch Township, forming the Mehoopany coal basin, continues as a gentle fold across the county about eight miles southeast of the Wilmot anticline, and leaves the county about two miles east of West Nicholson in Nicholson Township. Southeast of the Bernice syncline the rocks are nearly horizontal except for minor undulations as far as the eastward extension of the White Deer anticline beyond the southeast corner of the county.

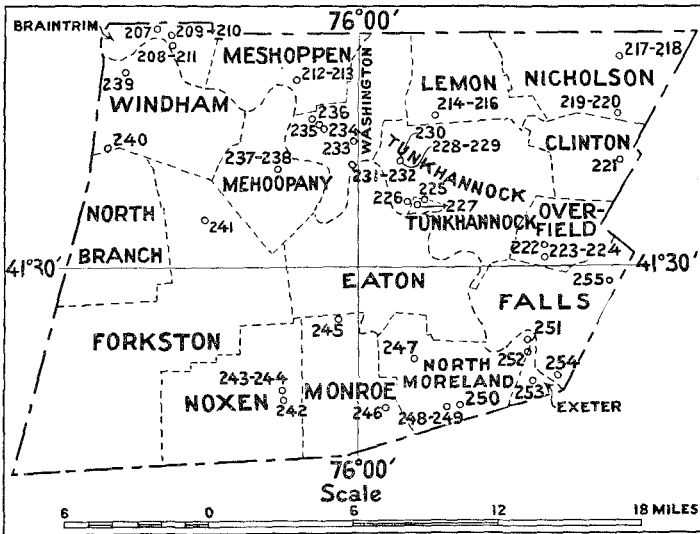


Figure 18. Map of Wyoming County showing location of water wells

WATER-BEARING FORMATIONS

[See pp. 41-54 for further description]

Glacial drift.—The drift covering in the regions above stream level consists largely of till, although there are small patches of water-stratified material in some places. Small supplies of water are obtained from the glacial drift by dug wells and springs, but the lowering of the water table in the summer often renders these supplies unreliable. In the higher regions drilled wells obtaining water from the underlying bed-rock are in general more satisfactory sources of water supply.

Outwash consisting of commingled clay, sand, and gravel lines the banks of the North Branch of Susquehanna River and its tributaries in Wyoming County, filling the valleys in many places to a height of more than 200 feet above the present streams. A great thickness of outwash gravel has accumulated at the mouth of Tunkhannock Creek. Well 227,

in Tunkhannock, penetrated 150 feet of drift before encountering bedrock. Terraces are found at many places along the river and its larger tributaries, and in the vicinity of South Easton there are at least four successive terraces, the highest of which stands about 200 feet above low water.

In the vicinity of Falls the gravel deposits are especially deep, and the well of the Wyoming Sand & Stone Co. (254) penetrated 160 feet of "quicksand" and gravel before reaching bedrock. Plate 6-A shows two well-developed terraces along Tunkhannock Creek just east of Nicholson.

Along the North Branch of Susquehanna River the extensive glacial outwash deposits of sand and gravel are a source of ground water, although they have been utilized very little. Well 225 of the Tunkhannock Water Co. indicates that at least some of the outwash gravel is capable of yielding a considerable quantity of water. Well 209 of the Farmers Cooperative Mercantile Co., in Skinners Eddy, obtains water from outwash gravel, and the water is under sufficient artesian head to rise 2 feet above the surface. With more modern methods of finishing such wells by means of screens or strainers, larger yields could be obtained, and wells that might ordinarily prove to be failures on account of fine sand might be successfully operated. Wells obtaining water from glacial outwash are likely to be stronger than bedrock wells, although the discontinuous and lenticular character of the permeable layers generally makes the chance of getting water more uncertain.

Pottsville formation, Mauch Chunk shale, and Pocono sandstone.—The Pottsville formation, Mauch Chunk shale, and Pocono sandstone crop out only on the summits of the high mountains in the southwest corner of Wyoming County. The Pocono extends as far east as Tunkhannock. At the crest of Dutch Mountain, on the eastward extension of the Bernice syncline, is a small area of coal known as the Mehoopany coal basin, presumably contained in the Pottsville formation, for from the work of the Pennsylvania Second Geological Survey it is believed that the Pottsville is the highest formation represented here. Probably several hundred acres is underlain by workable semianthracite, and although it has been mined and used locally for many years its small area and inaccessibility render it relatively unimportant commercially.

These formations are not important as sources of ground water because they crop out in almost inaccessible, forested country, and it is believed that no water wells have been drilled into them.

Catskill continental group.—The rocks of the Catskill continental group underlie all of Wyoming County except for small areas of Carboniferous and Chemung rocks. The Catskill sequence is similar to that in Susquehanna County and includes all of the formations from the Mount Pleasant down to the New Milford formation.

Almost all the drilled wells in Wyoming County derive their water from rocks of the Catskill. It is believed that in most places the water occurs principally in joints and bedding planes in the sandstone. Three wells in the Catskill are reported to yield 200 gallons a minute or more. (See wells 226 and 243). The water obtained from the Catskill is of good quality and is reported to be satisfactory for most purposes.

Chemung formation.—The marine Chemung formation is exposed only in the northwest corner of the county. It is not an important source of

ground water in Wyoming County. The area of outcrop is small and the water is likely to be salty and contain hydrogen sulphide, particularly from deep wells. A few drilled wells (207, 208, 210, 211) in Laceyville and Skinners Eddy obtain rather poor water from this formation (see analysis 210).

ARTESIAN CONDITIONS

The structure of the rocks in Wyoming County is relatively simple, but artesian pressure sufficient to cause the water level to rise some distance above the point at which it was first encountered is found in many of the bedrock wells. Although several minor synclines are present the only flowing wells recorded (209, 210) are on the crest of an anticline in Skinners Eddy. Well 209 is 90 feet deep, and the water level was reported to stand 2 feet above the surface. On July 17, 1930 the well flowed 0.22 gallons a minute. This well obtains water from glacial outwash gravel lying just above the bedrock and the water is entirely satisfactory for drinking. Well 210, about 12 feet from 209, is 122 feet deep, and the water level is reported to stand 7 feet above the surface. It penetrated 96 feet of glacial outwash and was drilled 26 feet into the bedrock, ending in a sandstone of the upper Chemung formation. On July 17, 1930, this well flowed 3.05 gallons a minute of salty water with a pronounced odor of hydrogen sulphide and was unfit for drinking. Thus well 209 flows potable water with a head of 2 feet, and well 210 only a few feet away, flows salty water with a 7-foot head, indicating that the water in the two wells comes from different sources.

QUALITY OF WATER

Eight samples of water were collected from drilled wells and springs in Wyoming County, the analyses of which are tabulated on page 292. Three samples from the glacial drift were low in total dissolved solids and comparatively soft. Four samples from the Catskill formation had a moderate content of dissolved solids and were slightly hard. A sample of water from the Chemung formation (well 210) contained much more total dissolved solids, including 254 parts per million of chloride. This water has a salty taste and contains some hydrogen sulphide, which make it unpleasant for drinking, but it is being used for boiler feed water.

In 1881 the Mehoopany Oil Co. drilled a test well for oil on the bank of Mehoopany Creek $1\frac{1}{2}$ miles northwest of Lovelton. The well was drilled to a depth of 2,089 feet, and a very careful record was kept as to the nature and thickness of strata penetrated.² The company was unsuccessful in obtaining oil, but its carefully kept log is of geologic value and contains data on ground-water conditions at depths greater than those ordinarily attained by water wells. The driller reported "fresh water cased off at 280 feet; salt water cased off at 665 feet; a small spray of brackish water at 1,000 feet, and another at 1,590 feet." Thus, although some of the shallow wells in the Chemung obtain potable water, deeper wells and even some of the shallow ones are likely to encounter brackish or salty water.

PUBLIC SUPPLIES

The four public water supplies using ground water are tabulated below. Factoryville, Nicholson and Meshoppen are supplied by surface water, and the other villages depend upon individual wells and springs.

² White, I. C., op. cit., pp. 141-143.

All four of the places using ground water have one or more springs, and Mill City derives its entire supply from one spring. Laceyville, Tunkhannock and Noxen use drilled wells and springs. In each place the drilled wells are found to be more reliable than the springs, and it is probable that any increase in population will be best taken care of by an increased number of drilled wells. The Tunkhannock Borough Water Co. is the largest municipal user of ground water in the county and its public supply is the only one requiring treatment.

INDUSTRIAL SUPPLIES

With one exception all the industrial users of ground water are located northeast of the North Branch of Susquehanna River. The creameries are the chief industrial users. Five creameries use drilled wells, and one in Lemon uses a spring supply. The largest single industrial user of ground water is the J. K. Mosser Leather Corporation, at Noxen, southwest of the North Branch of the Susquehanna, which operates two large-capacity air-lift wells (well 243).

DOMESTIC SUPPLIES

Most of the domestic supplies in Wyoming County are obtained from springs and dug wells, and in some of the small villages they are obtained exclusively from springs. In some places the dug wells are said to go dry during the summer, but most of the springs were reported to be reliable. There are relatively few drilled wells in Wyoming County at present, but it is believed that eventually drilled wells will largely replace the dug wells, because they are less subject to contamination, are more reliable during dry seasons, and generally yield larger supplies of water.

Analyses of waters in Wyoming County

[Parts per million. Numbers less than 1200 correspond to numbers on map and in table of well data]

	210	217	224	225	231	243	1220 ¹	1221 ¹
Silica (SiO ₂)	23			16	16			
Iron (Fe)	.32			.02	.04			
Calcium (Ca)	41	39	28	19	46	43		11 ²
Magnesium (Mg)	8.8	6.3	7.5	3.3	9.5	5.6		
Sodium (Na)	165	32 ³	2 ³	14	23	44 ³		6 ³
Potassium (K)	1.5			1.1	1.7			
Carbonate (CO ₃)	0	6.9	0	0	0	0	0	0
Bicarbonate (HCO ₃)	173	115	63	76	153	102	44	31
Sulphate (SO ₄)	5.3	26	16 ²	21	12	5 ²	6 ²	10 ²
Chloride (Cl)	254	42	8.0	5.0	28	92	3.0	4.6
Nitrate (NO ₃)	.10	1.0	34	2.5	.75	.50		7.2
Total dissolved solids	589	213 ³	135 ³	111	223	246 ³	50 ³	56 ³
Total hardness as CaCO ₃ (calculated)	139	123	101	61	154	130		24 ⁴
Date of collection (1930)	July 22	July 21	July 17	July 22	July 21	Sept. 16	Sept. 17	Sept. 16

¹ 1220. Spring 1 mile north of Mill City; glacial drift; temperature 60° F. 1221. Spring 3/4 mile southwest of Noxen; glacial drift; temperature 54° F.

² By turbidity. ³ Calculated. ⁴ Determined.

Analysts: 210, 217, 224, 225, 231, 243, K. T. Williams; 1220, 1221, L. A. Shinn.

Public water supplies in Wyoming County derived from ground water

Place and Owner	Source	Geologic source	Storage (gallons)	Average daily consumption	Treatment	Remarks
Laceyville Laceyville Borough Water Co.	1 spring and 1 drilled well	Well in Chemung	30,000(?)	22 (?) consumers	None	Drilled well 168 feet deep.
Tunkhannock ¹ Tunkhannock Water Co.	Several springs and 2 drilled wells	Springs and one well in glacial drift, one well in Catskill	800,000	150,000-200,000 gallons	Chlorine gas	Also used for fire protection; see wells 225 and 226; analysis 225.
Mill City G. T. O'Dell	1 spring	Glacial drift	12,900±	25 consumers	None	See analysis 1220.
Noxen Mr. Davis	3 springs and 1 drilled well	Springs in glacial drift, well in Catskill	118,000	26,000± gallons	None	Drilled well used only as an auxiliary supply; serves all of the inhabitants; see analysis 1221, well 242.

¹Population in 1930 was 1,973. Figures available only for incorporated places.

Drilled wells in Wyoming County

No.	Location ¹	Owner or tenant	Topographic situation	Altitude above sea level ² (feet)	Depth (feet)	Diameter (inches)	Character of water-bearing material	Geologic horizon	Depth to which well is cased (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
207	Braintrim Twp. Laceyville	Vandervort Mills	River bank	-----	216	6	-----	Chemung	26	13	60	I	Moderate draw-down pumping 60 gallons a minute for 10 hours; slight odor of hydrogen sulphide.
208	Skidders Eddy	Dairymen's Co-operative Association	do	-----	182	6	-----	do	80	20±	20	do	Draw-down 60± feet pumping 20 gallons a minute for 8 hours; water reported to be hard; temperature 52°F; bedrock overlain by 60 feet of clay and "quicksand."
209	do	Farmers Cooperative Mercantile Co.	do	-----	90±	6	Outwash gravel	Glacial drift	90±	flows	.22	do	Water level 2 feet above surface; flow measured July 17, 1930; temperature 56°F.
210	do	do	do	-----	122	6	Sandstone	Chemung	96	flows	3.05	do	Water level 7 feet above surface; flow measured July 17, 1930; water is salty and has an hydrogen sulphide odor; see analysis 210; temp. 60°F. July 22, 1930; loam and "quicksand" 96 feet, shale 20 feet, sandstone (water-bearing) 6 feet.
211	do Meshoppen Twp.	-----	do	-----	120	6	-----	do	-----	-----	30	D	
212	Meshoppen	Mr. McClaren	Valley	-----	205	6	-----	do	98	30-40	-----	do	
213	do Lemon Twp.	Dan Russel	do	-----	50	6	-----	do	13	20±	-----	do	
214	Lake Carey	Mr. Geddens	Lakeside	-----	98	6	-----	Catskill	13	25±	10-15	do	Draw-down 40 feet pumping 10 to 15 gallons a minute.

215	do		do		70		Coarse sandstone	do	10			do	Water level is about 10 feet above the lake level; there are about 20 drilled wells near Lake Carey.
216	do		do		55	6		do	30	20±	15	do	Small draw-down pumping 15 gallons a minute.
217	Nicholson	Dairymen's Co-operative Association	Valley		150	4		do				I	See analysis 217; temp. 54°F. July 21, 1930; water is chlorinated.
218	do	Nicholson Pennsylvania Corporation	do		170	4	Sandstone	do		15±	large	do	
219	2 miles south of Nicholson	George Kelly	Hill		226	6		Catskill	106	70	20±	D	Small draw-down pumping 20± gallons a minute.
220	do	W. H. Meyers	do		115	6	Gray sandstone	do	32	60	60	do	Small draw-down pumping 60 gallons a minute for 3 hours.
	Clinton Twp.												
221	Factoryville	E. C. Frear	Hillside		100	6		do	30	3		do	Small draw-down.
	Overfield Twp.												
222	½ mile north-east of Lake Winola	Mr. Klenish	do		21			Glacial drift		15		do	Dug well; low in summer
223	¾ mile south-east of Lake Winola	DeWitt Werkheiser	do		147	8		Catskill		75±		do	
224	¾ mile south-east of Lake Winola	G. M. Smalser	do		143	6	Blue sandstone	do	20	72	19	do	Supplies 14 families; see analysis 224; temp. 50°F. July 17, 1930.
	Tunkhannock Twp.												
225	North of Tunkhannock	Tunkhannock Water Co.	Valley		60	10	Gravel	Glacial drift	60	15-20	33	P S	Water level lowers in summer; see analysis 225; water is chlorinated.
226	West of Tunkhannock	do	Hillside		275±	10		Catskill		90	200	do	Small draw-down pumping 200 gallons a minute for 15 to 20 hours.
227	Tunkhannock	Witch Hazel Distilling Co.	Valley		230		Sandstone	do	150	60	40	I	150 feet of drift overlying the bedrock.

Drilled wells in Wyoming County—Continued

No.	Location ¹	Owner or tenant	Topographic situation	Altitude above sea level ² (feet)	Depth (feet)	Diameter (inches)	Character of water-bearing material	Geologic horizon	Depth to which well is cased (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
228	2 miles north-west of Tunkhannock	J. H. McCain	Near hilltop	-----	30	-----	-----	Glacial drift	-----	10	-----	D	Dug well; low in summer; also use springs which yield 150 gallons a day.
229	do	do	do	-----	230	6	Red and gray sandstone and shale	Catskill	53	157	5.5	DS	Draw-down 5 feet pumping 15 gallons a minute.
230	2½ miles north-west of Tunkhannock	William Comstock	do	-----	14-16	-----	Drift (?)	Glacial drift(?)	-----	10±	-----	D	Low in summer.
231	Washington Twp. Vosburg	Excelsior Dairy	Hillside	-----	144	6	Coarse sandstone	Catskill	44	22±	33	I	Water reported to be hard; see analysis 231; temp. 54°F. July 21, 1930; draw-down 4.5 feet pumping 33 gallons a minute for 4 hours.
232	do	do	do	-----	72	-----	-----	do	44(?)	22±	small	N	20 feet from well 231.
233	1 mile north of Vosburg	T. S. Kintner	do	-----	45	-----	-----	Glacial drift	-----	38	-----	D	Dug well; dry in dry seasons.
234	2 miles north-west of Vosburg	C. E. Dietrich	do	-----	124	-----	-----	Catskill	-----	65	-----	do	
235	2½ miles north-west of Vosburg	do	Hilltop	-----	416	8	Sandstone	do (?)	No casing	155	2	do	Draw-down 5 feet pumping 10 gallons a minute for 5 minutes.
236	2½ miles north-west of Vosburg	John Williams	Upland	-----	229	-----	-----	do (?)	30-40	100±	5—	do	Large draw-down pumping 5 gallons a minute.
	Mehoopany Twp.												
237	Mehoopany	F. B. Robinson	Hillside	-----	72	6	-----	Catskill	-----	-----	-----	do	Permanent supply.
238	do	E. Howden	do	-----	58	4	-----	do	-----	-----	-----	do	Low in summer.

	Windham Twp.																		
239	$\frac{1}{2}$ mile east of Golden Hill	J. W. Furman	Slope		24			Chemung		4			DS	Dug well; 20 feet to bedrock.					
240	Stowell	John O'Mara			30		Sandstone	Catskill		15			D	Dug well; dry in summer; 4 feet to bedrock.					
	Forkston Twp.																		
241	Forkston	Mr. Krawson	Valley		45			do	35	10±			do						
	Noxen Twp.																		
242	Noxen	Mr. Davis	Hillside	980	110			do	5	10-15	6-	P S	Large draw-down pumping 6 to $3\frac{1}{2}$ gallons a minute for $1\frac{1}{2}$ hours.						
243	do	J. K. Mosser Leather Corporation	Valley	1,000	385	6		do	60+(?)	40	200-300	I	Two wells, nearly same in depth and yield; first well flowed before second well was drilled; see analysis 243; temp. 52°F. Sept. 16, 1930.						
244	do	do	do	1,000	60	6	Gravel	Glacial drift	60	30	small	N	Abandoned; pumps dry.						
245	Monroe Twp. Evans Falls	Peter Brond	do		12±		Sand	do		8		D	Dug well; low in summer; water reported to be slightly hard.						
246	1 mile east of Beaumont	Harper Evans		1,280	95	6	Gray sandstone	Catskill	16	50	3-4	do							
	North Moreland Twp.																		
247	Vernon	J. H. Coleman	Upland	1,100	30			Glacial drift		26	20	do	Dug well; never dry; moderate draw-down pumping 20 gallons a minute for 10 minutes.						
248	$\frac{1}{4}$ mile north-west of Center Moreland	J. W. Winters	do	1,300±	251	6	Sandstone	Catskill	5	80	20	do	Small draw-down pumping 20 gallons a minute for $1\frac{1}{2}$ hours; water reported to be slightly hard.						
249	Center Moreland	Commonwealth Telephone Co.	Near hilltop	1,260	160	4	do	do	10	50±		do							
250	$\frac{1}{2}$ mile east of Center Moreland		Hillside	1,200	120	6		do	40	40±		do							
251	West Falls	Mr. Siglin	Valley	686	84	6	Green sandstone	do	24	24±	large	do							
252	$\frac{1}{2}$ mile south of West Falls	Otto Thomas	do	620	161	6	do	do	118	40	15	do	Draw-down 25 feet pumping 15± gallons a minute for 1 hour.						

Drilled wells in Wyoming County—Continued

No.	Location ¹	Owner or tenant	Topographic situation	Altitude above sea level ² (feet)	Depth (feet)	Diameter (inches)	Character of water-bearing material	Geologic horizon	Depth to which well is cased (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water ³	Remarks
253	Exeter Twp. 1½ miles south of West Falls	W. F. McQue	Hillside	750	153	8-6	Gray sand-stone	Catskill	95	12	20—	D	Draw-down 72 feet pumping 20 gallons a minute.
254	Falls Twp. 2 miles south-east of Falls	Wyoming Sand & Stone Co.	Valley	609	166	6	-----	do	160	35	7-8	do	Drawdown 65 feet pumping 7 to 8 gallons a minute for 1½ hours; bedrock overlain by 160 feet of "quicksand" and gravel.
255	1¼ miles north-west of Schultsville	Don Dickinson	Hilltop	1,255	210	6	-----	do	30	30±	-----	DS	

¹ If no distance is given well is located in town.

² Generally estimated from nearest contour line or bench mark on topographic map.

³ D—Domestic; I—Industrial; DS—Domestic and Stock; N—None; PS—Public supply.

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